Appendix 5

UNITED STATES ARMY CORPS OF ENGINEERS

Biological Assessment for Commercial Sand and Gravel Dredging on the Lower Missouri River

Great Lakes – Big Rivers Region
Mountain – Prairie Region

OCTOBER 2015

Prepared by
U.S. Army Corps of Engineers
Kansas City and St. Louis Districts

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SECTION 1

Introduction

In 2011, the Corps of Engineers completed a Final Environmental Impact Statement (Final EIS, FEIS) and issued a Record of Decision (ROD) for commercial dredging activities on the Missouri River; these documents disclosed environmental impacts associated with the 2011 permit decision and ongoing re-issuance of dredging permits. The selected alternative in the Final EIS and ROD contained certain tonnage and locale restrictions on dredging, in addition to, a monitoring program and adaptive management framework to limit dredging-related impacts. The EIS and ROD can be downloaded at:

http://www.nwk.usace.army.mil/Missions/RegulatoryBranch/MissouriRiverCommercialDredging.aspx

The dredging activities were within the historic geographic range of the threatened Northern long-eared bat (*Myotis septentrionalis*), endangered Indiana bat (*Myotis sodalis*), threatened piping plover (*Charadriusmelodus*), endangered least tern (*Sterna antillarum*), endangered pallid sturgeon (*Scaphirhynchus albus*) and threatened decurrent false aster (*Boltonia decurrens*). The potential direct, indirect and cumulative impacts of the proposed and alternative actions on federally listed species were discussed in Sections 3.10 and 4.8 and Chapter 5 and Section 4.1 and 7.2 of the ROD. Potential actions to mitigate impacts on endangered species were discussed in Chapter 6 of the EIS and ROD. After reviewing the current status of the listed species, the environmental baseline for the Action Area and the effects of the Environmentally Preferred Alternative, the USACE concluded in a 2011 Biological Assessment (BA) that the Environmentally Preferred Alternative would either have no effect or was not likely to adversely affect federally listed species within the Action Area; the United States Fish and Wildlife Service (USFWS) concurred with this determination in an email 30 March 2011 (Enclosure 1).

The existing commercial dredging permits will expire on December 31, 2015. The six applicants have applied for a renewal of their permits with slight changes to the overall extraction totals. The Corps issued a Public Notice (Notice) for a renewal of the Commercial Sand and Gravel Dredging permits on the Missouri River on 13 March 2015. On 3 April 2015 the USFWS responded to this Notice asking for more information regarding the proposed action's potential effects to the endangered Pallid Sturgeon (*Scaphirhynchus albus*) (Enclosure 2). The USACE agreed to update their 2011 BA to address new information that was available for the Pallid Sturgeon and the potential effects of the action on the species.

This BA has been prepared in compliance with Section 7 of the Endangered Species Act of 1973 (ESA), as amended (16 United States Code §1531-1543). The BA evaluates the anticipated effects on federally listed threatened or endangered species of the issuance of permits by the U.S. Army Corps of Engineers (USACE) for commercial dredging of sand and gravel from designated reaches of the Lower Missouri River (LOMR), between river mile (RM) 0.0 and 500.0. The USACE has determined that their action potentially may affect federally listed species and therefore warrants consultation with the U.S. Fish and Wildlife Service (USFWS) pursuant to Section 7(a)(2) of the ESA. The specifics of the USACE-proposed federal action are described in more detail in Section 3. The species identified and evaluated in this BA are:

- Pallid sturgeon, *Scaphirhynchus albus*, Endangered;
- Least tern, *Sterna antillarum*, Endangered;
- Piping plover, *Charadrius melodus*, Threatened;
- Nortern long-eared bat, *Myotis septentrionalis*, Threatened;
- Indiana bat, *Myotis sodalis*, Endangered; and
- Decurrent false aster, *Boltonia decurrens,* Threatened.

On September 1, 2010, the USFWS issued a final rule determining that shovelnose sturgeon (*Scaphirhynchus platorynchus*) should be treated as threatened due to similarity of appearance to the endangered pallid sturgeon in areas where they commonly coexist, such as the Missouri River (75 Federal Register [FR] 53598). However, the ruling extends take prohibitions only to activities associated with commercial fishing. All other activities in areas where the two species overlap and that are conducted in accordance with applicable laws and regulations will not be considered take under the regulations designating shovelnose sturgeon as threatened (75 FR 53598). Therefore, shovelnose sturgeon is not considered further in this BA, as take is not currently prohibited for activities associated with commercial sand and gravel dredging in the LOMR.

SECTION 2

Consultation to Date

Consultation with the USFWS has been ongoing since the beginning of the ESA. **Error! Reference source not found.** summarizes consultation history between the USACE and USFWS for Commercial Dredging on the Lower Missouri River since 1994.

Date	Description
March 18, 1994	USACE Kansas City District submitted a BA of potential impacts of Missouri River commercial dredging submitted to USFWS.
October 9, 2002	USACE St. Louis District sent a letter to USFWS proposing additional restrictions for proposed Missouri River commercial dredging permits and finding that the activity was not likely to adversely affect the pallid sturgeon or other endangered or threatened species or their critical habitat.
January 17, 2003	USFWS sent a letter to the USACE St. Louis District concurring with the previous USACE finding conditioned on several permit conditions in addition to those proposed by the USACE.
June 27, 2003	USACE issued a Public Notice for re-authorization of Missouri River commercial dredging permits.
July 28, 2003	USFWS responded to the Public Notice for re-authorization of Missouri River commercial dredging permits.
January 12, 2004	USACE issued a Public Notice for authorization of proposed Muenks Brothers dredging permit.
March 8, 2004	USFWS responded to Public Notice for authorization of proposed Muenks Brothers dredging permit.
March 31, 2004	USACE Kansas City District sent the dredgers a letter transmitting comments received in response to the Public Notice referred to above for their Response and Rebuttal. USFWS had recommended several additional permit conditions including a dredge exclusion zone for some tributaries, river chutes, side channels, and areas adjacent to conservation lands (Missouri River Mitigation Project lands; FWS refuge lands; and Missouri Department of Conservation wildlife areas).
February 18, 2005	USFWS sent a letter to the USACE Kansas City District in response to objections and recommendations from the dredgers regarding proposed dredge exclusion zones. The letter makes some concessions and some requests.
March 27, 2007	USFWS sent a letter to the USACE Kansas City District expressing concerns about the delay by the USACE in making the permit decision but agreeing with the need for an EIS.
August 20, 2007	USACE Kansas City District completed the Environmental Assessment and sent the initial proffered dredging permits to the dredgers for permits good through 2009 when an EIS was expected to be completed.
October 30, 2009	USACE sent a letter requesting concurrence by the U.S. Fish and Wildlife Service (USFWS) with the determination that a 1-year extension of the Missouri River commercial dredging permits to allow for completion of the EIS would not adversely affect federally listed species. In that letter, concurrence was sought for the species and habitats to be covered in the assessment.
November 17, 2009	USACE sent a memorandum suggesting that the area of potential effect is the Lower Missouri River, its tributaries, and adjacent river banks within the Missouri River floodplain.

Date	Description
December 3, 2009	USFWS sent a letter to USACE with comments in response to the USACE letter requesting concurrence and agreed with the determination that the proposed permit extension would not adversely affect the pallid sturgeon (Scott pers. comm. 2009).
Late 2009	Correspondence between USACE and USFWS in which USFWS stated that new research and discoveries had been carried out on the pallid sturgeon since publication of the previous BA and that a new BA needs to be developed incorporating this recent research to support a conclusion of project effects.
January 22, 2010	USACE sent a letter to USFWS to verify the appropriate species list to evaluate in a BA.
February 10, 2010	USACE received a response from USFWS with species concurrence.
March 23, 2010	Telephone log documenting call (L. Dominguez, ENTRIX) to USFWS biologist Jane Ledwin regarding assessment of threatened and endangered plants.
December 16, 2010	Because the FEIS could not be finished before mid February USACE sent a letter to USFWS that determined that a three-month extension of the Missouri river commercial dredging permits would not adversely affect federally listed species.
December 27, 2010	USFWS sent a letter concurring that extending the Missouri River commercial dredging permits for three more months (through March 31, 2011) was not likely to adversely affect federally listed species, primarily because little dredging would be done during those cold months.
January 14, 2011	USACE submitted a Draft BA to USFWS for review.
February 24, 2011	USACE met with USFWS biologist Jane Ledwin to discuss her questions and concerns about the Draft BA and identify needed revisions.
March 30, 2011	Via email, the USFWS responds to the USACE's BA with a concurrence that the proposed action was not likely to adversely affect listed species.
March 13, 2015	USACE issued a Public Notice for re-authorization of Missouri River commercial dredging permits.
April 3, 2015	USFWS responded with a "non-concurrence" to USACE's ESA determinations made in Public Notice. Specifically, the USFWS stated that new research and discoveries had occurred for the pallid sturgeon since publication of the previous BA and that an updated BA needs to be completed incorporating this recent research to support a conclusion of project effects
August 14, 2015	USACE met with USFWS biologist Jane Ledwin to discuss her questions and concerns about the Draft BA and discuss results from the Dredgers' required bed and water surface profile surveys.

Table 2-1 Summary of Consultation with U.S. Fish and Wildlife Service

SECTION 3

Description of the Proposed Action

3.1 INTRODUCTION

3.1.1 REQUESTED TONNAGES

The requested sand and gravel extraction totals for the Missouri River Commercial Dredging Companies (Permit No.'s: NWK-2011-00361, NWK-2011-00362, NWK-2011-00363, NWK-2011-00364, MVS-2011-00177, MVS-2011-00178) from within the five predefined segments of the LOMR in Kansas and Missouri are identified in Table 3-1. If re-issued, the permits would authorize dredging for an additional period of 5 years. The methods and timing of dredging in the 2015 applications are identical to those assessed in the 2011 FEIS and ROD, except for requested increases in tonnage in three river segments (St. Charles, Jefferson City, and Waverly) as described in Tables 3-1 and 3-2 below.

Application Number	Applicant Name	River Reach Requested	Annual Tons Of Material Authorized By 2011 DA Permits	Annual Tons Requested (2015 Renewals)
NWK 2011-00361	Capital Sand Company, Inc. (Capital Sand)	St. Charles Segment	140,000	**300,000***
		Jefferson City Segment	1,350,000	**1,350,000**
		Waverly Segment	370,000	**2016 – 370,000**
				2017 – 452,500*
				2018 – 535,000*
				2019 – 617,500*
				2020 – 700,000*
NWK 2011-00362	Hermann Sand and Gravel, Inc. (Hermann) Sand)	St. Charles Segment	120,000	**150,000***
		Jefferson City Segment	120,000	**150,000***

Application Number	Applicant Name	River Reach Requested	Annual Tons Of Material Authorized By 2011 DA Permits	Annual Tons Requested (2015 Renewals)
NWK 2011-00363	Holliday Sand and Gravel Company (Holliday Sand)	Waverly Segment	770,000	**2016 – 770, 000**
				2017 – 847,000*
				2018 – 924,000*
				2019 – 1,001,000*
				2020 – 1,078,000*
		Kansas City Segment	2011 – 1,200,000	**540, 000**
			2012 – 900,000	
			2013 – 850,000	
			2014 – 800,000 (*permit modification*)	
			2015 – 540,000	
		St. Joseph Segment	860,000	**860,000**
NWK 2011-00364	Con-Agg of MO, L.L.C. (Con-Agg)	Jefferson City Segment	160,000	**160,000**
MVS 2011-00177	Limited Leasing Company 63369	St. Charles Segment	990,000	**990,000**
MVS 2011-00178	J.T.R. Inc. (Jotori Dredging)	St. Charles Segment	460,000	**460,000**
Total (All Dredgers Combined)	2016			**6,100,000**
	2017			**6,259,500**
	2018			**6,419,000**
	2019			**6,578,500**
	2020			**6,738,000**

Table 3-1 Missouri River Dredging Tonnages and Segments as Proposed by the Applicants

(*) Denotes a requested variance from tonnage authorized in 2011 DA permits.

2016–2020 totals were calculated from river reach segment data. The totals presented in this table differ from those presented in the USACE's March 13, 2015 Public Notice due minor calculation errors and a modified request by Capital Sand for the Waverly Segment that was not represented in the Public Notice.

Application Number	Year	Actual Tonnage Extracted	Annual Tons Of Material Authorized By 2011 DA Permits
All Dredgers Combined	2011	3,523,022	6,540,000
	2012	3,169,239	6,240,000
	2013	3,627,531	6,190,000
	2014	4,104,187	6,140,000
	2015	-	5,880,000

Table 3-2 Cumulative Tons Extracted per Year versus Authorized Tonnages (2011–2015)

3.1.2 USACE PROPOSED ACTION

The largest requested changes from the 2011 DA permits are requests by Holliday Sand and Gravel Company (Holliday) and Capital Sand Company, Inc. (Capital Sand) to annually increase tonnage in the Waverly Segment. Other smaller increases have been requested by Capital Sand and Hermann Sand and Gravel, Inc. (Hermann Sand) in the St. Charles and Jefferson City segments (Table 3-1).

The Kansas City Segment has stabilized since 2011. Thus, the USACE is proposing to authorize dredging levels in this Segment identical to the levels permitted in 2015.

The USACE plans to deny the increased tonnages in the Jefferson City and St. Charles Segments by Capital Sand and Hermann Sand due to the lack of bed aggradation trends in these Segments [further discussed in 3.4.1 and analyzed in Section 6.1.2.1 of this BA]. In the Jefferson City and St. Charles segments, the USACE plans to authorize tonnages identical to those in the 2011 permits for each company (Table 3-5).

The USACE plans to authorize the increased tonnages in the Waverly Segment due to the bed aggradation trend in the segment. The analysis used by the USACE to determine the proposed increases are expected to fall within the bounds of the least environmentally damaging practicable alternative (LEDPA), are described in the USACE FEIS and ROD (USACE 2011b, USACE 2011c) and located in Section 3.4.1 of this BA. The ROD concluded that the LEDPA would result in no more than slight degradation throughout the LOMR, between river mile (RM) 0.0 and 500.0, in the short term and the long term (USACE 2011b). An individual analysis will also be included within a supplemental Environmental Assessment (EA), to be completed by the USACE, prior to the authorization of the Missouri River Commercial Dredging permits; however, to aid the Service in concurring with the

USACE's effects determination, the framework and justification for this decision is located in Section 3.4.1 of this BA.

A moderate decrease in authorized tonnages in the St. Joseph Segment is planned by the USACE. The USACE is proposing to decrease extraction totals in this Segment from 860,000 tons to 330,000 tons due to the degradation trends identified prior to this permitting cycle and verified in the bathymetric surveys conducted by the dredgers in 2014.

The Action Area (Figure 3-1) and conservation measures associated with the proposed action, , limits on localized dredging intensity, monitoring and adaptive management, operational measures, resource protection zones (some added), and compliance and monitoring measures, would be identical, if not more stringent, to those described in the ROD and the 2011 DA permits (Section 3.5).

3.2 DREDGING OPERATIONS

Dredging for sand and gravel on the LOMR will be conducted using hydraulic suction-head or cutter-head dredges mounted on movable barges. The dredge consists of mechanical equipment mounted on a barge that can be moved into position and anchored during dredging operations. The dredge barge is held in a fixed position during dredging by deploying large, fortress-style anchors from the forward corners of the barge on the end of 1,000- to 2,000-foot-long cables. By selectively manipulating the length of each anchor cable, the dredge can be moved forward, backward, and from side to side during the dredging operation. From a single anchoring position, a dredge can operate in an area approximately 1,000–2,000 feet in length and approximately 400–500 feet in width before moving the anchors. Some dredges include piles (called "spuds") that can be raised and lowered to the river bottom, to assist with maintaining the dredge position.

All dredging operations will use one of two types of hydraulic suction dredges. In the upper and middle segments, the currently authorized operations use dredges with cutter heads and onboard processing equipment. Dredges with suction heads and simple onboard screens are used in the lower segments of the LOMR. During dredging, the dredging head (with or without a cutter head) and a suction line are mounted on a boom (called a ladder) that is lowered to the river bed. Sediment is removed from the river bottom until the suction head comes into contact with hard materials (such as bedrock, large rock substrates, or consolidated sediment layers)—at which time the suction head does not advance further into the river bottom, and the amount of bottom sediments sucked into the suction head is greatly reduced. The dredge boom is then raised, the dredge is relocated, and excavation recommences.

The characteristics of bottom sediments in the LOMR vary with location. Dredging in the LOMR produces material of highly variable grain size, including small stones, coarse and fine gravels, sands of various sizes, fine material, and some lignite particles. Sand and gravel suitable for commercial use in building materials must meet material specifications defined by grain size distribution and proportion of each grain size that may be included in the product. The dredged material is passed though screens and settling-sorting equipment to achieve a desired grain size distribution that meets material specifications for various commercial uses. The material ranging from 0.1 to 4.0 millimeters (mm) is typically retained, and the unwanted material is discharged into the river. Marketable material is loaded onto barges that are tied alongside the dredge barge. The barges, typically ranging from 120 to 200 feet long and from 30 to 45 feet wide, are pushed upstream and downstream by towboats. During loading and transport, river water drains from the loaded sand and is discharged back to the river via scuppers on the barge. For dredging operations in the lower segments of the LOMR, where discharge screens are used to sort the dredged material, this runoff is a considerable volume. No specific testing of overboard discharge of dredge slurry water or undesirable size fractions of sediment is conducted, as the discharged material is not exposed to any processing other than sorting.

Once loaded, barges are moved downstream to a sand plant, where they are tied next to an unloading barge with conveyor transfer equipment. Earth-moving equipment is used to transfer the sand and gravel to a conveyor system that moves it ashore; following offloading at the sand plant, empty barges are returned to the dredge site for reloading. Offloaded material may be washed to remove lignite, resorted into various classifications, and stored for sale and transport. The terminal where the unloading barge is located (the sand plant) typically includes a system of overhead conveyors, stackers, and earth-moving equipment for moving and stacking bulk materials; truck loading facilities; scales; and equipment maintenance facilities.

Sand plant facilities typically have direct access to local, state, and interstate highway systems for product transport. The onshore terminal may also include moorage for dredge barges, transport barges, and towboats. To the extent practicable, vessel maintenance is performed at the onshore facility.

Table 3-3 identifies the dredging equipment, barges, and towboats that will be used by the applicants. The location, approximate size and storage capacity, length of water frontage, and adjacent land use of each sand plant facility currently operated or proposed by the dredging applicants is shown in Table 3-4.

Permit Applicant	Dredge Barges	Towboats	Barges
J.T.R., Inc.	2	2	4
Limited Leasing Company	3	4	20
Capital Sand Company, Inc.	3	3	12
Hermann Sand & Gravel, Inc.	1	2	4
Con-Agg of MO, L.L.C.	0	0	0
Holliday Sand & Gravel Company, L.L.C.	2	3	9

Table 3-3 Dredging Production Equipment to Be Used by the Applicants

Dredging typically occurs from March through December. During the coldest periods, when ice formation may hinder operations and demand for aggregate and sand is lowest, dredgers typically perform annual maintenance on their equipment. Dredging operations are typically performed only during daylight hours but are capable of operating around the clock.

Seasonal flows, the configuration of river training structures and bends, and sediment transport in the river generate a pattern of sediment deposition that dredge operators can reasonably predict in some locations. Based on previous experience, dredge operators frequently return to known locations of sediment deposits that meet sand and gravel market criteria. Being able to return to specific locations minimizes the time for dredge movement, produces more consistent dredge material, maximizes yield for a given period of dredging, and reduces the cost of operation. Experience gained over time helps the dredge operators identify these prime locations. Moving to a new reach requires the dredger to search for new or other prime locations, increasing costs and reducing the certainty of supply.

Company	Plant Name	Location (river mile)	Size (acres)	Storage Capacity	Adjacent Land Use
Holliday Sand & Gravel Company, L.L.C.	St. Joseph	447.7	11	100,000	Industrial
	Riverside	371.8	28	200,000	Industrial
	Randolph	359.9	17	100,000	Industrial
Total			**56**	**400,000**	
Capital Sand Company, Inc.	Lexington	317.2	30	135,000	Agricultural
	Carrollton	287.0	12	10,000	Agricultural
	Glasgow	226.2	3.5	38,000	Industrial
	Boonville	196.6	4	50,000	Agricultural
	Rocheport	186.3	10	68,000	Agricultural
	Washington	65.4	21	150,000	Agricultural
	Jefferson City	143.5	9	202,000	Agricultural/ Industrial
Total			**89.5**	**653,000**	
Hermann Sand & Gravel, Inc.	Jefferson City	146.6	12 [a]	150,000	Agricultural
	Hermann	96.9	17 [a]	150,000	Agricultural/ Industrial
Total			**29[a]**	**400,000**	
J.T.R., Inc.	St. Charles	16.7	2[a]	60,000	Industrial
	Riverview	31.2	2	40,000	Industrial
Total			**4**	**100,000**	
Limited Leasing	Bridgeton[b]	44.0	30	90,000	Industrial
	Chesterfield[b]	28.0	86	190,000	Industrial
	F. Belle[c]	8.2	10	50,000	Industrial
	Alton[d]	203.9	3	N/A	Industrial/ Commercial
Total			**N/A**	**230,000**	

Notes:
N/A = Not applicable.
[a] Numbers are approximate.
[b] Owned by LaFarge.
[c] Owned by Central Stone.
[d] The Alton facility is located on the Mississippi River and is served by Lower Missouri River river miles 0–12 in the St. Charles segment.

Table 3-4 Sand Plants in the Lower Missouri River

Since 2008, each permitted dredge operator has been required to continuously report its dredge location using global positioning system (GPS) coordinates and its operating status. This reporting is required to monitor compliance with permit conditions and to better understand where dredging is occurring.

3.3 INTERRELATED AND INTERDEPENDENT ACTIONS

An interrelated action is an activity that is part of the proposed action and depends on the proposed action for its justification. An interdependent action is an activity that has no independent utility apart from the action under consultation. The following paragraph addresses actions or programs that have been determined to be interrelated to, or interdependent with commercial dredging on the LOMR.

In addition to the proposed commercial dredging operations, a number of facilities or sand plants located onshore at various locations along the LOMR are required for unloading, processing, sorting, temporarily storing, and distributing commercial sand and gravel produced by the dredging operations.

3.4 ALTERNATIVES ANALYZED

In accordance with 33 CFR 325, Appendix B and 40 CFR 1500–1508, the FEIS (USACE 2011) evaluated the applicants' Proposed Action and a range of practicable alternatives to meet the basic and overall purpose of the Proposed Action. The lower Missouri River was divided into five segments: St. Charles (river mile [RM] 0 – RM 130; Mississippi River to Osage River); Jefferson City (RM 130 – RM 250; Osage River to Grand River); Waverly (RM 250 – RM 357; Grand River to Blue River); Kansas City (RM 357 – RM 391; Blue River to Platte River); and St. Joseph (RM 391 – RM 498; Platte River to Rulo, Nebraska). The basis for defining the river segments is given in Section 3.3 of the FEIS (USACE 2011).

Alternatives selected for each segment were based on the condition that dredging would be distributed more broadly throughout the segment than had occurred under past dredging practices (pre-2011). If dredging were not distributed more broadly and were allowed to remain concentrated around the existing sand plants, the level of future river bed degradation and associated direct and indirect impacts under these alternatives would be expected to be locally moderate to substantial. The level of expected future bed degradation and associated direct and indirect impacts can be reduced by (1) reducing the approved annual dredging volumes, especially in the areas with the highest levels of bed degradation; and (2) distributing dredging more broadly along the length of the river to reduce localized dredging intensity. Thus, in addition to designation of a total dredging amount for each segment, target levels for dredging intensity and how those limitations could be applied will also reviewed. The analytical basis for these target levels is discussed in Section 3.4.6.3 and Appendix A of the FEIS (USACE 2011). Requested tonnages exceed the highest evaluated alternative for the Waverly dredging segment in the 2011 FEIS; if the Corps authorizes the increased tonnages in this segment it will evaluate a new (higher) alternative to determined if the requested amounts will cause more than slight bed degradation to the LOMR.

To estimate potential dredging intensity effects on river bed degradation, historical dredging data were used to determine where dredging occurred (dredging reach) and at what intensity (annual average dredging amount in tons/mile). This information was then compared with observed patterns of local bed degradation by analyzing changes in local bed elevations in relation to dredging intensities using linear regression. The results suggest that dredging up to approximately 60,000 tons/mile/year is a level of local dredging intensity that is reasonably unlikely to result in local bed degradation.

3.4.1 Segment Limits

This Section and Section 3.1.2 identifiy the companies, amounts, and locations, that the USACE intends to authorize. The USACE has determined that the proposed dredging amounts for St. Joseph, Kansas City, Waverly, Jefferson City, and St. Charles segments are practicable and therefore the LEDPA when considering monitoring data collected from 2011-2014 and presented in Section 6.1.2.1 of this BA.

Application Number	Applicant Name	River Reach Requested	Annual Tons Of Material Authorized By 2011 DA Permits	USACE Proposed Action Tonnages
NWK 2011-00361	Capital Sand Company, Inc. (Capital Sand)	St. Charles Segment	140,000	**140,000**
		Jefferson City Segment	1,350,000	**1,350,000**
		Waverly Segment	370,000	**2016 – 370,000**
				2017 – 452,500*
				2018 – 535,000*
				2019 – 617,500*
				2020 – 700,000*

Application Number	Applicant Name	River Reach Requested	Annual Tons Of Material Authorized By 2011 DA Permits	USACE Proposed Action Tonnages
NWK 2011-00362	Hermann Sand and Gravel, Inc. (Hermann) Sand)	St. Charles Segment	120,000	**120,000**
		Jefferson City Segment	120,000	**120,000**
NWK 2011-00363	Holliday Sand and Gravel Company (Holliday Sand)	Waverly Segment	770,000	**2016 – 770, 000**
				2017 – 847,000*
				2018 – 924,000*
				2019 – 1,001,000*
				2020 – 1,078,000*
		Kansas City Segment	2011 – 1,200,000	**540, 000**
			2012 – 900,000	
			2013 – 850,000	
			2014 – 800,000 (*permit modification*)	
			2015 – 540,000	
		St. Joseph Segment	860,000	**330,000***
NWK 2011-00364	Con-Agg of MO, L.L.C. (Con-Agg)	Jefferson City Segment	160,000	**160,000**
MVS 2011-00177	Limited Leasing Company 63369	St. Charles Segment	990,000	**990,000**
MVS 2011-00178	J.T.R. Inc. (Jotori Dredging)	St. Charles Segment	460,000	**460,000**
Total (All Dredgers Combined)	2016			**5,380,000**
	2017			**5,539,500**
	2018			**5,699,000**
	2019			**5,858,500**
	2020			**6,018,000**

(*) Denotes a requested variance from tonnage authorized in 2011 DA permits.

Table 3-5 The USACE Proposed Action Extraction Totals

The USACE is proposing no increases in the Jefferson City and St. Charles segments. These segments experienced bed change in the line with the natural variance commonly witnessed in the Missouri River but neither segment has demonstrated an aggradation trend when considering recent and historic data. Specifically, the Jefferson City segment slightly aggraded and the St. Charles segment was stable during the 2011 permitting cycles (Table 6-2) but this alone is not enough evidence to conclude a trend is occurring; for this reason the requested increases will not be authorized.

Increases in the Waverly Segment are outside the range of alternatives considered in Section 3.4.6.3 and Appendix A of the FEIS (USACE 2011c). The selected alternative (B) in the 2011 ROD was the highest alternative (1,140,000 tons) evaluated; it represented 15% of the bed load during average-flow. However, the USACE analyzed and selected extraction of bed loads much higher than this in two segments (USACE 2011b, USACE 2011c). For instance in the 2011 ROD, the selected alternative (C) in the Jefferson City Segment authorized the removal of up to 38% of the bed load at below normal-flow conditions, all the while, the Segment aggraded 0.28 feet between 2011 and 2014 (Table 6-2). This provides a basis for understanding sediment removal thresholds and corresponding bed trends of the River in response to dredging. Applying these same principles, the proposed action, if authorized, would permit the removal of up to 35.5% bed load at below normal-flow conditions in the Waverly segment. The Waverly segment has experienced an aggradation trend since 1998 (USACE 2011c) even with a substantial high flow event in 2011 that significantly flushed the system of sediment. Acknowledging these two facts, the USACE believes the authorization of an additional 738,000 tons of material will not lead to more than slight degradation in the short and long-term in the Waverly Segment

The USACE proposes a moderate decrease in authorized tonnages in the St. Joseph Segment for the 2016 permits. The USACE is proposing to decrease extraction totals in this Segment from 860,000 tons to 330,000 tons due to the degradation trends identified in FEIS (USACE 2011c) and Section 6.1.2.1 of this BA. The reduced tonnage was selected from the range of alternatives analyzed in the USACE's FEIS, Section 3.4.6.3 and Appendix A (USACE 2011c). The proposed extraction totals for this Segment align with Alternative (C) in the Final EIS and represent a 62% decrease in authorized tonnage limits; just as the 2011 selected Alternative (B) was not anticipated to lead to more than slight degradation in the short and long term, the newly selected Alternative (C), should not cause degradation trends in the St. Joseph Segment. It should be noted, that Alternative (A) would be a viable alternative in which the tonnage (350,000 tons) would be reduced from previous authorizations and represents a worst case scenario from a bed load perspective (Alternative (A) would allow 10 percent of the estimated bed material load under below-average flow conditions). However, given the level of degradation observed in the Segment and the fact that the average total extraction for this reach is

174,283 tons, authorized extraction levels under Alternative (C) offer the greatest reduction in dredging while still allowing the Segment to be a viable reach for the Dredgers.

Section 6.1.2.1 of this BA explains how this degradation in the St. Joseph Segment is not spatially associated with ongoing dredging. Nonetheless, a reduction in extraction totals will prevent the exacerbation of degradation trends as they migrate upstream. In addition to the reduced tonnages, Water Surface Profiles will be evaluated yearly and Hydro-acoustic Bed Surveys will be conducted in 2019 to help identify ongoing River trends and adjust permitted dredging levels if necessary.

The USACE will not authorize dredging in the most degraded reaches of the St. Joseph Segment. This includes River Miles 390 to 413 and 426 to 434.

3.4.2 Limits on Localized Dredging Intensity

Applying the 60,000-tons/mile/year dredging target to each individual river mile throughout the entire river presents difficulties to both the USACE and the dredgers. Applying a 60,000-tons/mile/year dredging target to the most heavily dredged and degraded five-mile reaches of the river allow better management by the USACE and provides more flexibility to the dredgers. In 2011, the USACE identified 17 specific five-mile reaches with water surface profiles more than two feet lower in 2005 than in 1990 and with a five-mile moving average bed elevation averaged over 2007, 2008, and 2009 that was more than a foot lower than in 1998. These degraded reaches were between river miles 15 to 20, 25 to 35, 90 to 100, 140 to 150, 355 to 390, and 445 to 455. The USACE determined that limiting dredging to no more than 300,000 tons/year in each of these 17 five-mile reaches remains a practicable and necessary part of re-issuance of the 2015 permits. Based on bathymetric data (Section 6.1.2.1) there does not appear to be a need to place a 300,000 tons/year cap on any additional 5-mile reach.

3.4.3 Monitoring and Adaptive Management Framework

The USACE has also determined that a practicable and necessary part of the re-issuance of the 2015 permits is that water surface profiles are prepared annually by the USACE and a hydroacoustic bed elevation survey is provided by the dredgers in the fourth year of each permit cycle, if the USACE does not provide one through another study or river program. The USACE will evaluate the data and meet with the dredgers and state and federal agencies in October of each year to discuss the condition and trend of the river as shown by the most recent water surface profiles or surveys. Permits would be issued for five-year periods. During the five-year permit cycle, if the USACE determines from new data or analysis that additional measures should be taken to protect critical resources, it may modify, suspend, or revoke the permit at any time. Renewal of the dredging permits after five years would be a new Federal action requiring assessment of the prior NEPA document and assessment of any new information. In 2020, the data from the previous four years will be compared with the 2009 water surface profile and bed elevation baselines to evaluate if the permit limits and special conditions adequately limited the impact of dredging to no more than slight degradation across the river as projected by the EIS. Moderate to severe degradation instead of the slight degradation anticipated by the EIS would require a thorough review of the permit provisions and could result in reductions in authorized dredging reaches or quantities, or implementation of other mitigation measures in the new permit decision. Likewise, aggradation could allow for consideration of increased quantities.

As discussed in Section 6.3.1 of the FEIS (USACE 2011), low-flow water surface elevation and hydroacoustic bed elevation data (HBED) are two types of data that could be gathered to show river bed aggradation or degradation. Both have their advantages and disadvantages.

Advantages of low-flow water surface elevation data are the period of record that is available, the ability to collect data on the water surface and use it to estimate gross changes in bed elevation, the consistency of the data collected over a short period of time, and the low cost and effort for data collection. Its main disadvantage is the level of error and uncertainty resulting from the low number of physical measurements, the level of accuracy of the USGS stage and flow estimates, the interpolation of surface elevations and flow estimates between USGS gage stations, and normalization of the flows at the time of the survey to the CRP flow.

The advantages of using HBED for monitoring purposes are that it measures river bed elevations directly rather than using estimates from water surface elevations or models, surface water elevations are collected simultaneously, data exist for the whole Project area, and high-resolution data exist for 1998 (using a different protocol), 2007, 2008 (partial), and 2009. Disadvantages include high collection and data processing costs, the fact that water surface elevation data collected during HBED surveys would need to be normalized to a standard flow, the fact that the surface of the river bed varies with the flow, and the fact that a rigorous statistical analysis has not yet been done to determine what spatial density of sampling points and number of transects is sufficient to accurately show actual degradation or aggradation.

Low-flow water surface elevation data were collected every year (except 2011) and a HBED survey was conducted in 2014 for the lower 498 miles of the LOMR. These data have been incorporated into this BA (Section 6.1.2.1) and future data sets will be used to identify reaches that degraded or aggraded over the previous 5 years and will guide the adjustment of dredging in those reaches for the following permit cycle.

3.5 SPECIAL PERMIT CONDITIONS

The proposed dredging permits will include special permit conditions to ensure avoidance or minimization of impacts on environmental resources. Those special permit conditions are categorized as operational measures, resource protection zones, and compliance and monitoring measures.

3.5.1 Operational Measures

- If future operations by the United States require the removal, relocation, or other alteration, of the structure or work herein authorized, or if, in the opinion of the Secretary of the Army or his authorized representative, said structure or work shall cause unreasonable obstruction to the free navigation of the navigable waters, the permittee will be required, upon due notice from the Corps of Engineers, to remove, relocate, or alter the structural work or obstructions caused thereby, without expense to the United States. No claim shall be made against the United States on account of any such removal or alteration.
- Up to 10% of the permittee's authorized annual tonnage may be carried over each year to be extracted the following year. Annual tonnage with carryover may never exceed 110% of annual authorized tonnage. At the end of each year the permittee must notify the Corps in his annual tonnage report of any undredged tonnage that he intends to carryover.
- The permittee must discharge only suitable material that is free from toxic pollutants in other than trace quantities.
- The permittee must investigate for water supply intakes or other activities which may be affected by suspended solids and turbidity increases caused by work in the watercourse and give sufficient notice to the owners of affected activities to allow preparation for any changes in water quality.
- The permittee must employ measures to prevent dredged materials stored or disposed of on shore from running off or eroding into wetlands or tributaries to the Missouri River.
- The permittee must employ measures to prevent or control spilled fuels or lubricants from entering the waters of the United States.
- The permittee must store all construction materials, equipment, and/or petroleum products that are part of the on-shore operation, when not in use, above anticipated high water levels.

- The permittee may return unwanted dredged material and river water extracted from the Missouri River back to the Missouri River. The permittee must not dispose of waste materials, water, or garbage below the ordinary high water mark of any other water body, in a wetland area, or at any location where the materials could be introduced into the water body or an adjacent wetland as a result of runoff, flooding, wind, or other natural forces.
- The permittee must comply with all U.S. Coast Guard, State of Missouri, State of Kansas (RM 367 to 490), and USACE regulations concerning the prevention of navigation obstructions in navigable waters of the United States.
- The permittee must conduct operations in the Missouri River such that there will be no unreasonable interference with navigation.

3.5.2 Resource Protection Zones

Dredging can have a direct and immediate negative effect on various natural and manmade resources in the immediate area. To prevent or minimize these negative effects, dredging would generally be excluded in certain environmentally sensitive areas, in areas adjacent to certain infrastructure facilities, and in or near pallid sturgeon habitat. The specific resource protection zones within which dredging is prohibited are listed below. The USACE will provide the Dredgers with these exclusion zones in an electronic format that the dredge operator can use in the electronic dredge navigation system. The dredge operator is responsible for determining that the dredge does not operate within these exclusion areas. The dredge location is documented with GPS, and compliance with permit location exclusions is documented in reports submitted to the USACE.

- In permit conditions that specify a linear distance exclusion zone adjacent to a river feature, “dredging” refers to the operation of hydraulic cutter-head suction dredging. The exclusion zone distances will apply to and be measured from the end of the cutter head, rather than from a general point on the dredge.
- The permittee must confine dredging to between the Rectified Channel Lines (RCL) with the following restrictions. Dredging must be conducted in such a manner to preserve the structural integrity of the landmass landward of the RCL. This must be accomplished by maintaining an adequate "no dredging or discharging" zone riverward of the RCL so that material will stabilize into the dredging area at its natural angle of repose. This slope will vary depending upon river location and the type of material being dredged, but it is your responsibility to ensure that this shallow water interface landward of the RCL be maintained.

3.5.2.1 Levees, Pipeline Crossings, Dikes, and Bridges

Dredging too close to levees, pipelines, submerged utility crossings, bridge piers or abutments, dikes, revetments, water intakes, boat ramps, and natural river banks or islands, even at sustainable levels, can harm these structures either through direct physical contact or by undermining, exposing, destabilizing, or weakening these structures. The following condition is necessary to ensure that adverse impacts of the authorized dredging on navigation, flood control, and water intake structures and endangered species and their habitat are minimized

- The permittee must not dredge within 500 feet of any levee centerline, pipeline or submerged utility crossing; nor within 500 feet of a bridge pier or abutment; nor within 200 feet of any dike, revetment, or other structure built or authorized by the U.S. Government; nor within 100 feet of any normal bank line or island, without special authorization. When dredging is performed adjacent to river stabilization structures, the dredging may be conducted only in the present streambed of the river at the authorized locations. This condition represents only the minimum distances needed between dredging and structures and natural features and does not relieve the permittee from liability for damage arising from dredging. The permittee must be satisfied that dredging to these limits will not cause damage to public and private property.

3.5.2.2 Water supply

Dredging too close to water intake structures, even at sustainable levels, can harm these structures through direct physical contact; by undermining, exposing, destabilizing, or weakening these structures; and by negatively affecting water quality at the water intake. Dredging over horizontal collector wells can harm these wells by direct physical contact and by modifying the depth and physical characteristics of the river bed over the wells and negatively affecting the volume and quality of water pumped by the wells. The following conditions are necessary to avoid adverse impacts to municipal drinking water intake structures and provide a mixing zone sufficient to reestablish water quality to background conditions on the Missouri River; to preserve the existing permeable aquifer material and avoid adverse impacts to the horizontal collector wells; and to avoid adverse impacts to water intake structures and water quality of water users other than municipal drinking water providers.

- The permittee must not conduct dredging operations in a zone extending 4,000 feet upstream and 500 feet downstream from any municipal drinking water intake structures located along either bank of the river unless he obtains an exemption to this condition in writing from the Chief of the Regulatory Branch, Kansas City District, Corps of Engineers.

- The permittee must not conduct dredging operations in a zone extending 1,000 feet upstream and 1,000 feet downstream from any municipal drinking water horizontal collector wells located along either bank of the river unless he obtains an exemption to this condition in writing from the Chief of the Regulatory Branch, Kansas City District, USACE.

- The permittee must not conduct dredging operations in a zone extending 500 feet upstream and 500 feet downstream from any other water intake structures other than those used for municipal drinking water unless he obtains an exemption to this condition in writing from the Chief of the Regulatory Branch, Kansas City District, USACE.

3.5.2.3 Pallid Sturgeon Habitat

Previous dredging permit evaluations have determined that dredging in the specific locations authorized by those permits would not have any direct adverse effect on endangered species. The FEIS (USACE 2011) looked at a larger area of potential effect and identified various potential impacts that dredging could have on the endangered pallid sturgeon throughout the Action Area if dredging caused more than slight bed degradation in the short- and long-term or if dredging expanded into areas not previously dredged. The first condition is a practicable measure that is necessary to ensure that adverse impacts of the authorized activity on the pallid sturgeon and its habitat are evaluated and minimized when dredging expands outside currently dredged reaches. The pallid sturgeon habitat protection areas listed on Table 3-6 include specific areas where monitoring has most frequently found pallid sturgeon that could be directly impacted by dredging. The protection areas also include USACE shallow water habitat project sites that could be negatively impacted by dredging through physical disturbance and by removing coarse sediment from the bed load at locations where it is needed to form the sand and gravel bars in chutes that are a vital part of shallow water habitat. The USACE and USFWS will also reevaluate the list when dredgers request new or expanded dredging areas. At these times, habitat protection zones may be added for newly completed shallow water habitat projects or newly identified pallid sturgeon habitat areas; habitat protection zones may also be deleted if shallow water habitat areas have matured and/or no longer need protection from adjacent dredging.

- To avoid impacting endangered species, the permittee must confine dredging to the specified reaches listed in Table 3-6. If the permittee desires to expand or relocate their dredging operation outside the specified reaches, they must submit a request to this office identifying the proposed new limits, in river miles, and the location of the unloading facility to be employed. Approval of the requests, if granted, will be provided in writing with modified reaches identified on the Missouri River

Hydrographic Survey. Copies of the relocation requests must be furnished to the following agencies:

1. U.S. Fish and Wildlife Service, Columbia Field Office
2. Missouri Department of Natural Resources, Water Pollution Control Program
3. Missouri Department of Natural Resources, State Historic Preservation Office
4. Kansas Department of Health and Environment, Bureau of Water (for operations extending upstream of river mile 367)
5. Kansas State Historical Society, State Historic Preservation Office (for operations extending upstream of river mile 367)
6. Corps of Engineers, Kansas City District, Hydrologic Engineering Branch

- Dredging is prohibited within the reaches identified in Table 3-6 as pallid sturgeon habitat features

Missouri River Miles (including 0.25-mile buffer)		
Downstream Limit	Upstream Limit	Habitat Feature
44.25	44.85	RDB Centaur Chute
49.15	50.05	RDB Centaur Chute
56.85	59.05	LDB Chute/Island
58.55	61.25	RDB Chute/Island
89.75	91.10	RDB Island
89.90	91.45	LDB Loutre Slough
91.20	93.55	LDB Lunch Island
103.00	104.95	Both Gasconade Confluence and Dike Field
105.20	106.25	RDB Dike Field
115.20	115.95	RDB Island
118.40	119.15	RDB Dike Field
119.35	119.85	RDB St. Albert Chute
124.35	124.95	RDB St. Albert Chute
126.05	126.90	LDB Dike Field
127.50	130.20	Both Osage River Confluence and Dike Field
157.00	158.45	LDB Island
176.40	178.35	LDB Island/RDB Tadpole Island Chute
180.15	180.65	RDB Tadpole Island Chute
184.75	185.65	RDB Chute
186.90	188.20	RDB Chute and Dike Field
193.40	195.75	RDB Dike Field/Island
202.10	202.75	RDB Lamine River Confluence

Missouri River Miles (including 0.25-mile buffer)		
Downstream Limit	Upstream Limit	Habitat Feature
210.00	219.65	Lisbon/Jameson Complex
226.95	227.55	LDB Little Chariton Confluence
238.40	239.10	LDB Chariton River Confluence
249.65	250.30	LDB Grand River Confluence
269.85	271.35	RDB Shallow/Island
280.40	282.05	RDB Island
297.90	299.05	RDB Island
300.00	301.05	LDB Island
367.00	367.75	RDB Kansas River Confluence
390.85	391.45	LDB Platte River Confluence
456.75	457.25	LDB Worthwine Chute
458.75	459.25	LDB Worthwine Chute
462.65	463.25	LDB Nodaway River Confluence
478.55	479.15	RDB Wolf Creek Confluence
494.55	495.20	RDB Big Nemaha River Confluence

Source: USACE 2011c
Notes:

LDB = Left downstream bank.
RDB = Right downstream bank.

Table 3-6 Pallid Sturgeon Habitat Areas Protected from Dredging on the Lower Missouri River

3.5.2.4 Degraded Reaches

If dredging was not distributed more broadly and was allowed to remain concentrated around the existing sand plants and other degraded reaches, the level of future river bed degradation and associated direct and indirect impacts under the proposed action would be expected to be locally moderate to substantial. There would also likely be some loss of shallow water habitat in these areas of moderate to substantial bed degradation. The following condition is necessary to ensure that dredging results in no more than slight degradation throughout each river segment but particularly in the most severely degraded reaches and near some existing sand plants.

- No more than 300,000 tons of material shall be extracted within one year from each five-mile reach of the Missouri River between river miles 15 to 20, 25 to 35, 90 to 100, 140 to 150, 355 to 395, and 445 to 455. When the Corps' dredge report database indicates that extraction in a five-mile reach has reached 300,000 tons, all dredgers authorized to operate within that reach will be notified that it is closed to further dredging for the remainder of the calendar year unless the permittee requests and receives a waiver in writing from the Chief of the Regulatory Branch, Kansas City District, U.S. Army Corps of Engineers.

- No dredging shall occur in the Missouri River between river miles 390 to 413 and 426 to 434.

3.5.3 Compliance and Monitoring Measures

USACE has concluded that the proposed action with some adaptation to make it practicable should result in no more than slight degradation throughout the LOMR in the short- and long-term. These conclusions were based on the use interpretation of sediment transport equations and underlying data, the results of which include some level of uncertainty. While the results and the interpretation of the effects of bed degradation are based on the best currently available scientific data, sediment transport and estimates of previous bed degradation are indicators rather than accurate predictors of future degradation. The following permit conditions are part of a process to monitor key variables in the LOMR system throughout the 5-year permit cycle and provide information needed to determine whether dredging levels or permit restrictions should be adjusted. Such a monitoring and reevaluation process will allow the uncertainty inherent in the modeling and analysis of bed degradation to be addressed. It also will reduce the risk of potentially significant impacts, increasing the confidence that adjustments could be made to address impacts while they are relatively small. The permit conditions are also necessary to ensure that the dredgers comply with the conditions restricting where and how much material may be dredged.

- Within 30 days of execution of the permit, the permittee must provide a Dredge Monitoring Plan (DMP) for each individual dredge plant to the Regulatory Branch of the USACE, Kansas City District for approval. The DMP must show how the permittee will monitor, record, and report the cutter-head position, cutter-head operating status, extraction tonnage, and the presence of any hard substrates, mussel shells, or unusual concentration of gravel in an impartial, unbiased, reliable, and accurate manner. The DMP must include the specifications of the process and the Dredge Monitoring System (DMS) including sensors, hardware, software, communications devices that will: gather data; perform quality control on those data; calibrate, test, and repair sensors/data reporting equipment when they fail; and transfer the data to the Regulatory Branch of the U.S. Army Corps of Engineers, Kansas City District. The DMS must include automated differential Global Positioning System (DGPS) equipment (or other comparable system) operating with a minimum accuracy level of 1-3 meters horizontal Circular Error Probable with horizontal positions tied into the UTM Zone 15 NAD 83 (feet) coordinate system recorded to the nearest foot. The DMS must always be on, recording cutter-head position and operating status every 5 minutes, 24-hours a day, 365 days a year, even when the dredge is not operating. The DMS must measure the amount of material removed from the river for each day the dredge is operational. The extraction material shall be measured by one of the methods described in the attached Standard Operating Procedure for Hydrographic Surveying and Dredge Monitoring. Faulty sensors or other components of the DMP system must be repaired within 96 hours. The DMS must not be inoperable more than 5% of the time. The permittee must install an approved DMS and have it inspected by the Regulatory Branch of the U.S. Army Corps of Engineers, Kansas City District within 120 days of execution of the permit or the permittee must cease dredging operations until it is installed and inspected or the permittee submit a justification of the delay and an installation schedule and get an extension of this deadline in writing from the Chief of the Regulatory Branch, Kansas City District, USACE.

- The Corps of Engineers periodically surveys the river as part of the management and operation of the Bank Stabilization and Navigation Project. If the Corps of Engineers for any reason has not surveyed the river in the fourth year (2019) of the five-year permit cycle, the authorized dredging companies must have the lower 498 miles of the LOMR surveyed during the summer months in accordance with the Standard Operating Procedures for Hydrographic Surveying and Dredge Monitoring. The survey shall be completed between June and September of 2019 and submitted to the USACE by January 1, 2020.
- If any part of the authorized work is performed by a contractor, before starting work the permittee must discuss the terms and conditions of this permit with the contractor and must give a copy of this entire permit to the contractor. After the initial 120 days of this permit, any contracted dredges or barges must also be equipped with and operate in accordance with an approved DMP as required in Special Condition "b". The DMP and system must be approved by the Regulatory Branch of the U.S. Army Corps of Engineers, Kansas City District prior to starting work.

3.6 ACTION AREA

The Action Area considered in this BA is defined as the geographic area within which the direct or indirect effects (physical, chemical, and/or biotic) of the proposed federal action will occur, and conforms closely to the geographic scope of the FEIS (USACE 2011). It includes the main channel and floodplain of the LOMR from the confluence of the Missouri and Mississippi Rivers in St. Louis, Missouri (RM 0) to Rulo, Nebraska at RM 500 (see Figure 3-1). The Action Area also includes perennial tributaries joining the LOMR for a distance of 0.25 mile upstream or to the first upstream control point. A "control point" includes any natural streambed feature or human-made structure that provides grade control and controls or impedes the upstream progress of a headcut.

The Action Area falls within the Interior Highlands Management Unit, which is defined as the Missouri River from the confluence of the Grand River to the confluence of the Mississippi River, as well as the Mississippi River from Keokuk, Iowa to the confluence of the Ohio and Mississippi Rivers (USFWS 2014).

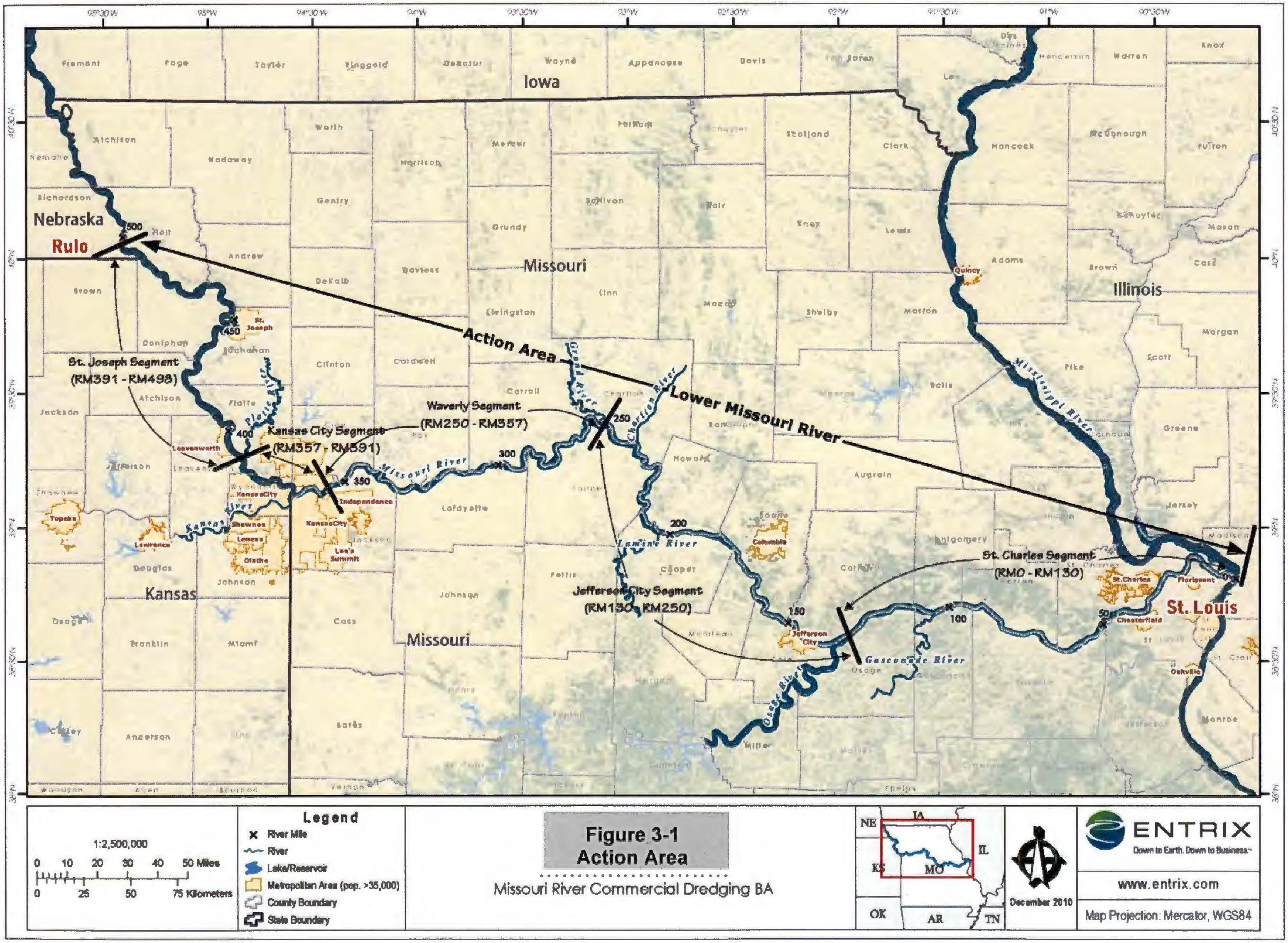

Figure 3-1
Action Area
Missouri River Commercial Dredging BA

SECTION 4

Status of the Species and Critical Habitat

4.1 PALLID STURGEON

4.1.1 Status Designation and Species Description

The pallid sturgeon (*Scaphirhynchus albus*) was federally listed as endangered under the Endangered Species Act (ESA) on September 6, 1990 (55 FR 36641). Findings have not yet been made on a 2010 petition to designate critical habitat, and none currently exists. The USFWS *Revised Recovery Plan for Pallid Sturgeon (Scaphirhynchus albus)*, published in 2014, provides a complete review of the species' status, including biology, population trends, habitats, threats, and recovery actions (USFWS 2014). The Recovery Plan states that the status of the species is currently stable and that the pallid sturgeon continues to be affected by a range of threats. While propagation and reintroduction efforts have restored or maintained the species in some reaches of the Missouri River, local extirpation within several reaches is expected to occur if these activities were to cease. The USFWS has determined that downlisting criteria have not been met, and the species remains listed as endangered under the ESA. Species Description

The pallid sturgeon is one of eight North American species of sturgeon, and one of three in North America in the genus *Scaphirhynchus*. The other two species within this genus are the shovelnose sturgeon (*Scaphirhynchus platorynchus*) and the Alabama sturgeon (*Scaphirhynchus suttkus*). The shovelnose sturgeon co-occurs with pallid sturgeon in the LOMR, and the Alabama sturgeon occurs only in the Mobile River Basin of Alabama and Mississippi (Williams and Clemmer 1991, USFWS 1993). The pallid sturgeon was first described by S. A. Forbes and R. E. Richardson in 1905, from nine specimens collected from the Mississippi River near Grafton, Illinois, in June 1904 (Forbes and Richardson 1905). Pallid sturgeon have a flattened, shovel-shaped snout; have a long, slender, and completely armored caudal peduncle; and lack a spiracle (Smith 1979). As with other sturgeon, the mouth is toothless, protractible, and ventrally positioned under the snout (USFWS 1993). The skeletal structure is primarily cartilaginous (Gilbraith, Schwalbach, and Berry 1988). Pallid sturgeon are one of the largest fish species in the Missouri/Mississippi River drainage; they can weigh up to 80 pounds and reach lengths of 6 feet. Adult pallid sturgeon from the Upper Missouri River are generally larger than adults collected from the LOMR and the Lower Mississippi River (USFWS 1993). They are similar in appearance to the closely related and more common shovelnose sturgeon; however, shovelnose sturgeon rarely weigh more than 8 pounds, and their back and sides are brown compared to grayish-white of pallid sturgeon (USFWS 1993).

Because of the pallid sturgeon's similar appearance to the more common shovelnose sturgeon, the issue of their status as separate species has been debated since the pallid sturgeon was listed as an endangered species in 1990. However, studies conducted by genetics and fishery researchers—from as early as 1905 but primarily since their listing in 1990—have provided genetic evidence that, when coupled with morphological and biogeographic data, indicate that pallid sturgeon should be considered a separate species under the ESA (USFWS 2000).

4.1.2 Distribution and Abundance

In the late 1900s, the pallid sturgeon was described as one of the rarest, although widely distributed, fish of the Missouri River and lower Mississippi River (downstream from the mouth of the Missouri River) (USFWS 1993). The historical (pre-impoundment) range of the pallid sturgeon extended from the Missouri and Yellowstone Rivers in Montana downstream to the Missouri-Mississippi confluence and the Mississippi River possibly from near Keokuk, Iowa, downstream to the Gulf of Mexico (Coker 1929, Bailey and Cross 1954, Brown 1955, Kallemeyn 1983) (Figure 4-1).

The Missouri Department of Conservation's Blind Pony Hatchery was the first to successfully spawn pallid sturgeon in 1992. Since1994, over 436,000 fingerling-size or larger pallid sturgeon have been stocked into the Missouri River, of which nearly 94,000 have been stocked in the LOMR between Gavins Point Dam and the mouth (Figure 4-2).

As part of implementation of the USFWS 2000 Biological Opinion (2000 BiOp) as amended in USFWS (2003), the USACE has developed a pallid sturgeon population assessment program to document current and long-term trends in pallid sturgeon population abundance, distribution, and habitat usage throughout the Missouri River system. Standardized sampling has been conducted annually since 2003. Starting in 2008, baited trotlines were added as a "non-standard" sampling gear. The number of pallid sturgeon sampled has substantially increased since the USACE started sampling

(Figure 4-1). This increase in the number of fish sampled is likely due to effective baited trotline sampling and pallid sturgeon stocking programs.

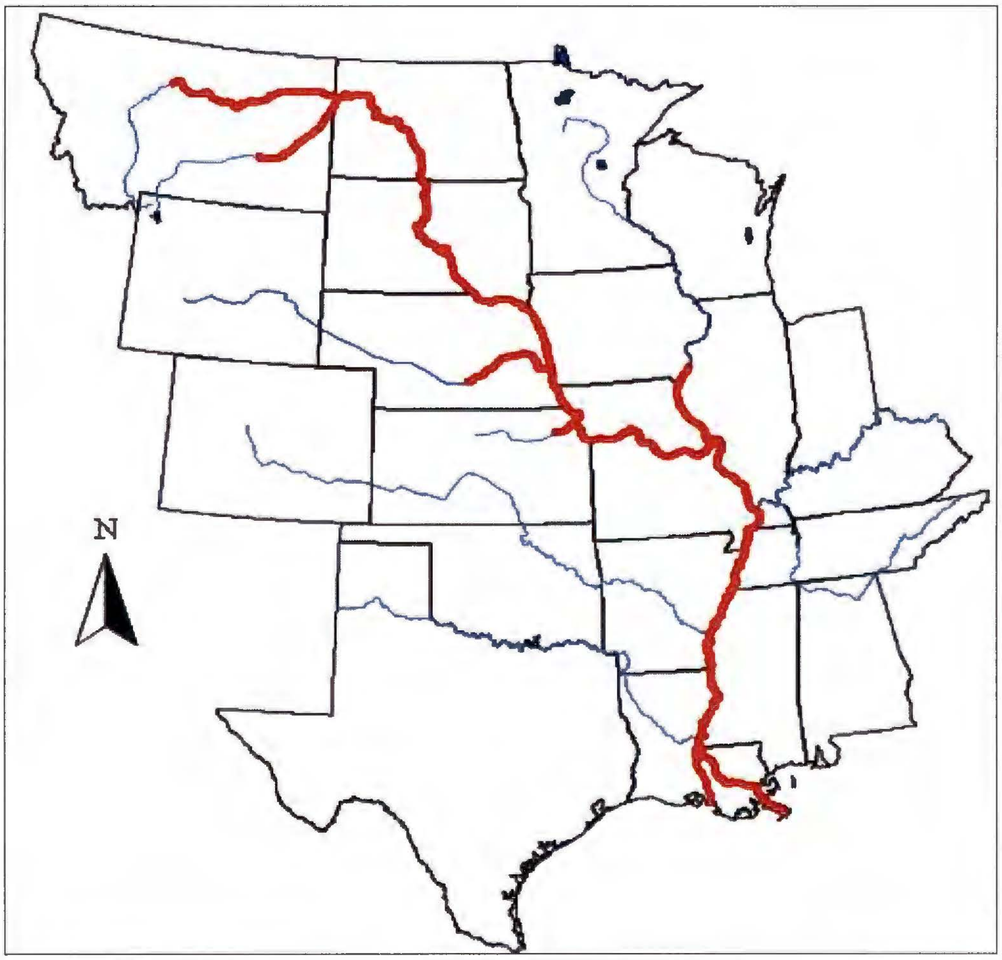

Figure 4-1 Pre-Impoundment Range of Pallid Sturgeon in Missouri and Mississippi Rivers

Source: Bailey and Cross 1954
Notes: Bold red line approximates historical range of pallid sturgeon.
Map not to scale.

Figure 4-2 Post-Impoundment Range of Pallid Sturgeon in the Missouri and Mississippi Rivers

Source: USFWS 2014 Revised Recovery Plan for the Pallid Sturgeon (*Scaphirhyncus albus*)

4.1.3 Life History and Ecology

Prior to 2000, little was known about this species in the wild (USFWS 2003). However, substantial new information about the status and life history of the pallid sturgeon has been gained in the last decade as a result of the USACE compliance activities for the 2000 BiOp. Although numerous studies since 2000 have documented pallid sturgeon behavior, life history, genetics, habitat use, and distribution, the general life history of pallid sturgeon is still considered complex.

Generally, pallid sturgeon migrate upstream to spawn (Wildhaber et al. 2007) (Figure 4-). Eggs incubate in these upstream locations, and the embryos and post-hatch larvae are free drifting downstream. The post-hatch larvae drift downstream and grow for approximately 10 days while they develop for exogenous feeding. The transition to the exogenous feeding larval stage approximately coincides with the transition to the utilization of benthic habitats. The early life history stages of pallid sturgeon are exceptionally vulnerable to predation and competition for food resources. The majority of adult fish species present in the LOMR feed on the zooplankton, which partially consists of pallid sturgeon and other fish in early life stages.

Many other environmental factors influence the survival and productivity of the pallid sturgeon at each of the various life stages. Scientists study the impacts of environmental factors such as temperature, various habitat uses, and predator-prey interactions on pallid sturgeon survival and population. Because pallid sturgeon habitat is so highly modified, it may be difficult for researchers to fully understand habitat requirements.

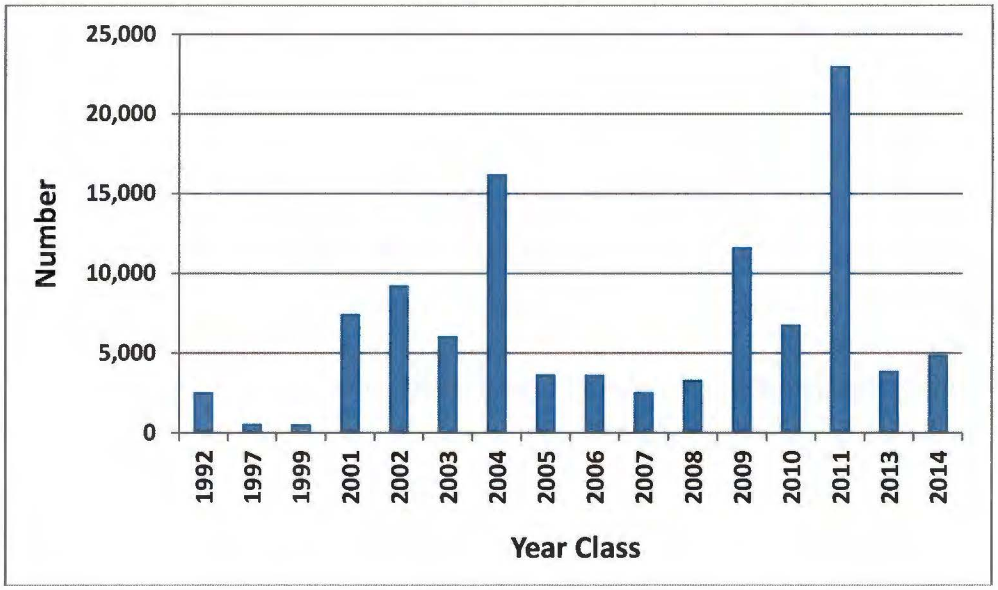

Figure 4-3 Numbers of Pallid Sturgeon Stocked (Reported as Yearly Equivalents) in the Lower Missouri River from Gavin's Point Dam to the Mouth.

Note: Stocking data is for fingerling-size, or larger, pallid sturgeon stocked into the LOMR between Gavins Point Dam and the mouth near St. Louis, Missouri. Data compiled by USACE based on stocking data reported for the LOMR (from Gavins Point Dam to the mouth) to USFWS by the Missouri River Basin State and Federal Hatcheries. Fingerling-sized sturgeon numbers were converted to yearling equivalents based on survival rates; therefore, actual stocking numbers were greater than reported here. No pallid sturgeon were stocked in 2012.

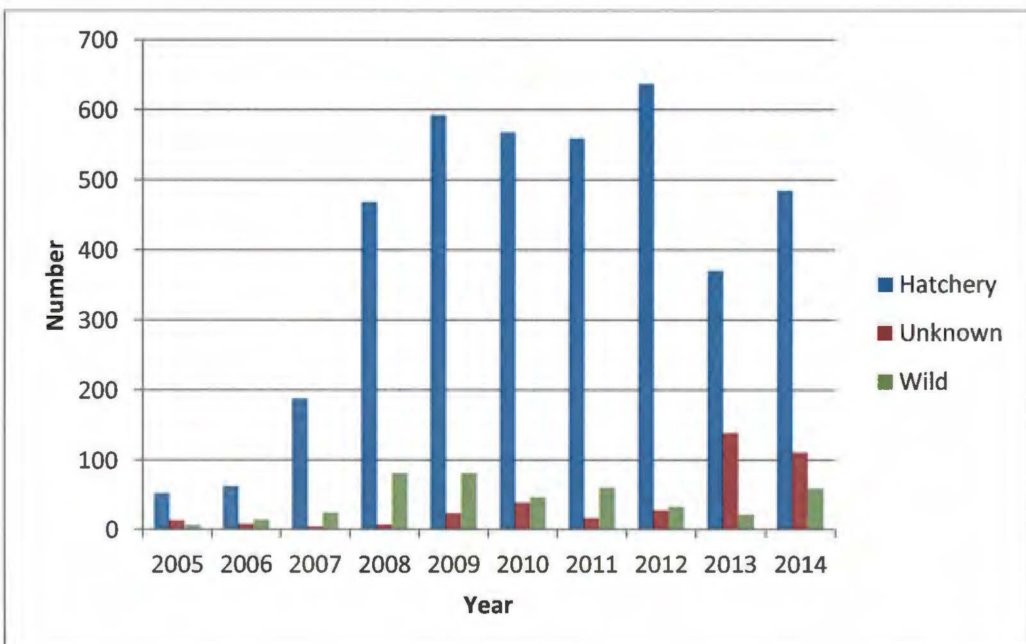

Figure 4-4 Numbers and Origin (Hatchery, Wild, Unknown) of Pallid Sturgeon Sampled on the Lower Missouri River from Gavins Point Dam to the Mouth (2005–2014).

Note: Data compiled by USACE based on sturgeon sampling data for the lower Missouri River from Gavins Point Dam to the mouth from the USACE Population Assessment database.

4.1.3.1 Habitat

The pallid sturgeon is a bottom-oriented, large river obligate species that inhabits the Missouri and Mississippi Rivers and some tributaries, from Montana to Louisiana (Kallemeyn 1983) and the Atchafalaya River (Reed and Ewing 1993).

Pallid sturgeon evolved in the diverse environments of the Missouri and Mississippi Rivers. Floodplains, backwaters, chutes, sloughs, islands, sandbars, and main channel waters formed the large-river ecosystem that provided macro-habitat requirements for pallid sturgeon and other native large-river fishes, such as paddlefish and other sturgeon species. It should be noted, however, that much of these data are based on habitat characterizations conducted in altered environments, some of which have experienced substantial anthropogenic influences, including altered hydrograph, stabilized banks, loss of natural meanders and side channels, fragmented habitats, and increased water velocities. Thus, the current understanding of microhabitat usage may not indicate preferred habitats for the species but may better define suitable habitats within an altered ecosystem.

Pallid sturgeon primarily use main channel, secondary channel, and channel border habitats throughout their range. Juvenile and adult pallid sturgeon are rarely observed in habitats lacking flowing water, such as backwaters or sloughs. DeLonay and Little (2002) reported that sturgeon were often found in locations of turbulence or complex current patterns, such as wing dike tips, off sand bars, or near steep drop offs, where current could vary by as much as 1.5 meters per second (m/s) between each side of the tracking vessel. They also found that sharp changes in bottom relief (e.g., drop offs, shelves, and scours), the spacing of engineered flow training structures, and the position of the thalweg appear to have greater influence over sturgeon location than depth, substrate, or velocity. In the channelized LOMR, adult pallid sturgeon have been observed in relatively higher numbers in channel border habitats associated with engineered structures but also have been observed using side channels and floodplain habitats with flowing water (Justin Haas *in litt.* 2013 as cited in USFWS 2014).

Habitat requirements of larval and young-of-year (YOY) pallid sturgeon remain under investigation across the species' range, primarily as a result of low populations and poor recruitment. A 2010 study of pallid sturgeon hatchery larvae released in the Missouri River found that concentrations "increased from the inside-bend location to the outside-bend location," with the highest probability of capturing larvae "adjacent to the bottom in the high-velocity thalweg of the channel" (Braaten et al. 2010).

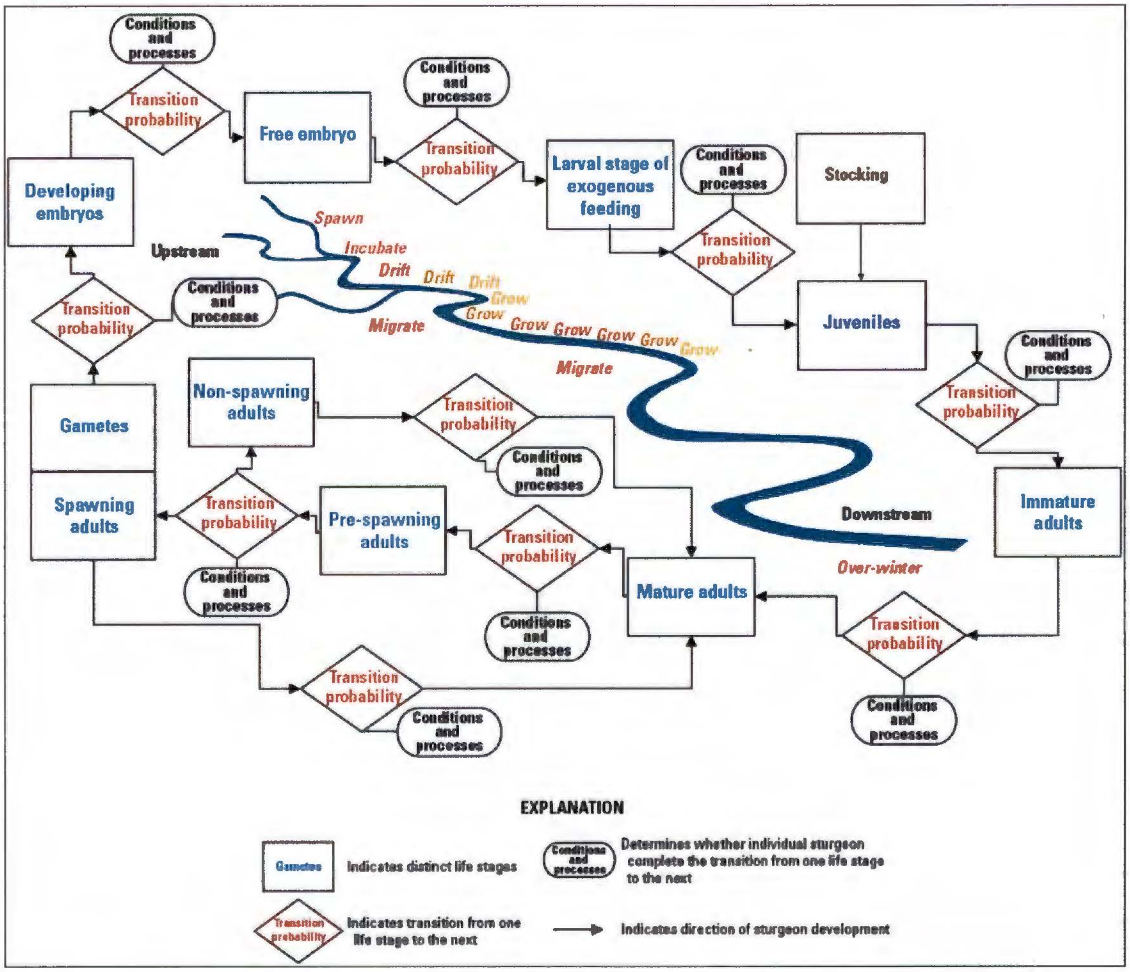

Figure 4-5 Conceptual Model of *Scaphirhynchus* Life History

Source: Wildhaber et al. 2007 with permission

4.1.3.2 Shallow-Water Habitat

Riverine habitat loss or alteration in the LOMR, especially loss of structurally complex shallow-water areas along stream margins and near sand bars, islands, backwaters, sloughs, chutes, and side channels, has been implicated as a strong contributing cause in the loss of several native Missouri River fishes (Johnson et al. 2006). "Shallow-water habitat" (SWH) originally was defined as aquatic habitat that is less than 5 feet deep with velocities of less than 2 ft/s, as measured during the August median discharge (USFWS 2003). Recent clarifications further refine the definition of SWH as habitat with a high degree of diversity in depth and velocity that contains dynamic alluvial processes.

SWH is an important riverine habitat in the LOMR that provides for primary and secondary productivity, forage fish production, and early life stage development for native Missouri River fishes (Hesse et al. 1993, 1989; Galat et al. 2005; Johnson et al. 2006; Jacobson et al. 2009b). SWH now is recognized as a highly underrepresented aquatic habitat type that was characteristic of the historical Missouri River. Historical changes, such as flow alterations and channelization of the LOMR, likely have substantially decreased the availability of shallow, slow-moving water (Johnson et al. 2006). Further, the LOMR has been and still is affected by reduced sediment inputs; these are important for creating and maintaining the diversity of habitats used by native fish such as the pallid sturgeon for reproduction and survival (USFWS 2003). While the use of SWH by young fish is supported by general river ecology theory, LOMR-specific data documenting the use of this habitat type by certain fish, such as pallid sturgeon, are only now starting to become available (Sterner et al. 2009, USACE 2009c).

The 2003 Missouri River Operations and Maintenance BiOp (USFWS 2003) indicated that the portion of the LOMR between the Platte River, Nebraska and the LOMR confluence with the Mississippi River is lacking sediment transport and sediment availability, which is adversely affecting pallid sturgeon habitat development and maintenance. Further, the USFWS has stated that larval and juvenile pallid sturgeon are limited by the quantity of SWH that provides rearing and refugia habitat (USFWS 2003). While the 2003 BiOp concluded that pallid sturgeon are limited by the lack of SWH, others have indicated that additional studies and modeling are needed to clearly establish which aquatic habitats are limiting pallid sturgeon population growth and other native fish populations (Johnson et al. 2006, DeLonay et al. 2009).

River flows and the corresponding river stage fluctuate daily, seasonally, and annually within the highly modified LOMR; and the presence of SWH is highly sensitive to flow regime (Johnson et al. 2006). Availability of SWH is generally high at the lowest discharges, when water is shallow and slow over marginal sand bars and when river discharges are just over bankfull stage (Johnson et al. 2006). As river flow and stage change, the quantity of aquatic habitat with shallow water and slow velocities changes. Additional studies are underway in the LOMR to better understand the role and importance of SWH and its locations, relationship to channel morphology, and flows (DeLonay et al. 2010).

It is hypothesized that SWH may be critical for larval retention, refugia, food production, or foraging for pallid sturgeon (Erwin and Jacobson 2015). Many of the research, resource management, and restoration plans and programs currently in place in the LOMR are designed to understand the role of SWH and to create more SWH through modifications of flow regime and channel geomorphology. The role of SWH as a key limiting factor in the recruitment of pallid sturgeon is a leading hypothesis currently being evaluated. now. However, this hypothesis remains unproven, and it is still not known whether lack of appropriate habitat is currently limiting pallid sturgeon (Erwin and Jacobson 2015; Gemeinhardt et al. 2015). Recent research has found little relationship between age-0 sturgeon captures and previous definitions of shallow water habitat (Gemeinhardt et al. 2015). Despite the fact that construction of SWH features has emerged as one of the primary restoration techniques used on the LOMR, it remains unclear whether these constructed features provide habitats that can be linked to growth and survival of specific pallid sturgeon life stages (Erwin and Jacobson. 2015; Gosch et al. 2015).

Multiple agencies are actively implementing a number of habitat actions to improve SWH in the LOMR (Jacobsen et al. 2015). One improvement action includes managing flows to maximize habitat. High-resolution 2-dimensional hydrodynamic models (e.g., ADH, TUFLOW) have been developed and applied to evaluate the potential outcomes of these managed flows on pallid sturgeon habitats for selected locations on the LOMR (Jacobson et al.2015). The emphasis of these modeling studies is on the creation of interception, food-producing, and foraging habitats for early life stages of pallid sturgeon. The models permit high-level spatial resolution (~1 m2) in describing areas of flows and depths preferred by larval sturgeon or conducive to food production available to exogenously feeding larvae. Managed flows or direct construction of SWH that provide these kinds of valued ecological functions are being examined by the agencies (Jacobson et al. 2015).

Ongoing efforts to restore SWH have complicated and offsetting results on total SWH area. The research of Papanicolaou et al. (2010), designed to quantify the additional SWH gained from notching dikes and to evaluate their performance under different flow conditions, demonstrates the complexities involved. Their numerical simulations showed that the SWH criterion for depth was more difficult to satisfy in the study reach than the SWH criterion for velocity, and results from the study suggested that notching dikes had limited impact on the net amount of SWH because the area gained from the bank line shift was offset by the area lost from the scour holes formation. Their research also showed that the performance of the SWH projects was highly discharge dependent; the dike projects could provide the minimum required SWH for some mean annual discharges but not for others.

The Missouri River Recovery Program (MRRP) seeks to mitigate near-term losses of Missouri River habitats, including SWH, and to assist with recovery of threatened and endangered species viahabitat restoration and flow modifications. Programs are in place through the MRRP to create SWH through mechanical techniques and LOMR flow modifications (MRRP 2007). The USACE's SWH Program aims to create habitat considered necessary for the recovery of endangered pallid sturgeon. Under the 1986

Bank Stabilization and Navigation Project Wildlife Mitigation Project (BSNP), the USACE began constructing chutes and backwaters in 1991 along the main channel, in an effort to restore SWH. As of 2001, these projects have been incorporated into the Shallow Water Habitat Program under BiOp compliance (NAS 2010).

The Reasonable and Prudent Alternatives in the 2000 and revised 2003 Missouri River Operations and Maintenance BiOps required the Corps to provide 20-30 acres/mile of SWH which represents approximately 20 percent of the SWH that existed prior to construction of the BSNP. The project area for the Shallow Water Habitat Program extends from near Ponca, Nebraska downstream to the mouth of the Missouri River at St. Louis. In 2015, USACE estimated that there are approximately 11,211 acres of SWH on the LOMR.

Two types of SWH projects are being constructed: (1) habitat creation at the margins of the navigable portion of the main river channel; and (2) construction or modification of chutes and backwaters on floodplains (NAS 2010). Constructed chutes are intended to have a hydrologic connection to the main channel at both high and low flows, have active bed sediment transport, and provide habitats that mimic historical depth and velocity conditions. Chutes provide shallower, more complex habitat than is found within the navigation channel; and they are designed to evolve over time, developing sinuosity and sandbars (NAS 2010). Constructed backwaters are connected to the main channel at only one end and therefore provide habitat with lower flow velocities.

The use of chutes to enhance habitat diversity and promote river and ecosystem restoration is a relatively new practice; only a small body of existing projects or research findings could be used to guide Missouri River chute construction and adjustments (NAS 2010). However, there are few other examples from within the United States or internationally of restoring floodplains of large rivers (NAS 2010); for example, see Buisje et al. 2002). The limited amount of past projects and substantive research results lends support for the adaptive approach to these projects that is being promoted by the USGS, the USACE, and others.

The effectiveness of SWH projects has been monitored under the Habitat Assessment and Monitoring Program (HAMP) since 2004. HAMP monitoring includes both biological response (fish species composition and richness) and habitat response (water depth, velocity, and substrate) to SWH creation, with sampling designed to relate these two components. Schapaugh et al. (2010) found no difference in age-0 sturgeon captures among river bends that had extensive habitat restoration when compared to bends without modification. but also suggested expansion of the spatial scope of a sampling unit from a single river bend to a larger extent. Other recent evaluations show that slow and shallow habitats may not be used by age-0 sturgeon as frequently as other habitat types in the lower Missouri River (Ridenour et al., 2011, Gosch et al., 2015, Gemeinhardt et al., 2015) and suggest that a better understanding of habitats that benefit age-0 sturgeon is necessary. As such, . it is not yet possible to draw clear conclusions about the biological effectiveness of the projects.

Earlier studies of geomorphology, physical habitat, hydrology, and ecological evolution of natural and created chutes have been conducted by scientists from outside the USACE (Jacobson et al. 2004, Jacobson 2006). Monitoring results of projects from 2006–2008 are summarized and analyzed in a 2009 report (Sterner et al. 2009), which includes monitoring of both fish response and geomorphic/habitat response (NAS 2010). SWH created through construction of chutes off the main channel, originally as part of the Missouri River Fish and Wildlife Mitigation Project, were evaluated. Jacobson et al. (2004) reported that natural and engineered chutes (Cranberry Bend, Lisbon Bottom, Hamburg Bend, and North Overton Bottoms) were providing substantial amounts of SWH, proportionately considerable amounts of SWH in the context of the overall river reach, and SWH over a wider range of flows. For example, the 2.2-mile-long Lisbon Bottom chute provides as much as 50 percent of all of the SWH that exists within the accompanying 9.6-mile reach of the river.

Substrate

Pallid sturgeon have been documented over a variety of available substrates but are often associated with sandy and fine bottom materials in the Upper Missouri and Lower Yellowstone Rivers (Bramblett and White 2001; Gerrity et al. 2005). Similarly, pallid sturgeon studied in the lower Platte River (Snook, Peters, and Young 2002; Swigle 2003; Peters and Parham 2008) and Middle Missouri River (Elliott, Jacobson, and DeLonay 2004; Spindler 2008) have also been associated with sandy substrates, which is the predominant substrate available. In these systems and others, pallid sturgeon appear to prefer underwater sand dunes (Bramblett 1996; Snook, Peters, and Young 2002; Elliott, Jacobson, and DeLonay 2004; Jordan et al. 2006).

Depth and Velocity

An assessment of the environmental characteristics at pallid sturgeon capture locations compared to surrounding reaches suggests that they are found in nearly the full range of habitats available to them. Although the literature supports the idea that adult pallid sturgeon do not select strongly for depth, there seems to be a stronger selection for velocity (Reuter et al. 2009). In the Upper Missouri River Gerrity et al. (2008) observed hatchery-reared pallid sturgeon in areas with mean depths from 2.31 - 2.48 m;

water column velocities 0.65-0.78 meter per second (m/s); and bottom velocities 0.67- . 0.87 m/s. Bramblett and White (2001) report wild pallid sturgeon using depths between 0.6 and 14.5 m in the Lower Yellowstone River, with average bottom velocities of 0.65 m/s. In the Missouri portion of the Missouri River, wild pallid sturgeon were collected from areas with bottom velocities between 0.3 and 0.73 m/s at depths ranging from 1.2 to 13.8 m (Carlson and Pflieger 1981).

Hatchery-reared pallid sturgeon studied between Fort Randall and Gavins Point Dams were most frequently observed at depths exceeding 3 m and where bottom water velocities ranged from 0.1 to 0.9 m/s (Jordan et al. 2006). Elliott, Jacobson, and DeLonay (2004), using more sophisticated equipment and location data from the same fish study, reported that pallid sturgeon used areas with velocities from 0.69 to 1.01 m/s and suggest that they were using velocity in proportion to availability within the reach.

Turbidity and Sediment

The association of pallid sturgeon with these large river systems has led to the conclusion that high sediment loads, and the associated elevated turbidity levels, are important for some of the pallid sturgeon life history components. Despite this conclusion, pallid sturgeon appear to be able to survive and utilize areas with consistently low turbidities (such as the impounded reaches of the Missouri River)(Braaten and Fuller 2002, 2003; Erickson 1992; Jordan et al. 2006; Peters and Parham 2008) and it is unknown whether low turbidity is a significant limiting factor for survival of larval pallid sturgeon. Jordan et al. (2006) show pallid sturgeon surviving below Fort Randall Dam, South Dakota where routinely captured in areas with turbidity as low as 5 to 12 nephelometric turbidity units (NTU). In Lake Sharpe, South Dakota, pallid sturgeon were found most frequently in water with measured turbidity values of 80–100 NTU. Conversely, in a more natural system like the Yellowstone River, wild and hatchery origin pallid sturgeon have been found in areas with turbidity levels seasonally exceeding 1,000 NTU. These data suggest that individual juvenile and adult pallid sturgeon can survive over a wide range of turbidity levels. Peters and Parham (2008) provide a variety of data that indicate the Lower Platte River experiences both annual and seasonal changes in turbidity, and the levels reported for the Lower Platte River encompass levels associated with pallid sturgeon found elsewhere. Sediment is an important variable in environmental restoration of a river system like the Missouri River. Currently, it is not fully understood if high sediment loads are fundamentally important to individual juvenile and adult fish given the variability of turbidity previously reported. The general consensus is that sediment concentrations and transport are as important as the quantity and flow of water, are the basic building material for river landforms that support habitat for native fauna, and have been important to the evolution and adaptation of native fishes such as pallid sturgeon (NAS 2010). Thus, areas defined by high sediment levels and subsequently high turbidity levels, and fluctuate seasonally and annually, may better mimic natural pre-alteration variability within the LOMR.

4.1.3.3 Reproductive and Developmental Biology

Pallid sturgeon are long lived, with females reaching sexual maturity later than males (Keenlyne and Jenkins 1993). Male pallid sturgeon are relatively sedentary, spending long periods in the same locale, but others been documented embarking on long migrations (Chojnacki and DeLonay 2014). The Comprehensive Sturgeon Research Project (CSRP) has tagged and is actively tracking male and female pallid sturgeon throughout the Missouri River basin and has documented such long migrations. A reproductive-aged male tagged at RM 177 near Boonville, Missouri in late 2013 traveled over 415 miles upstream at an average rate of 6.5 miles/day during the spring spawning season. Upstream and downstream migrations combined for that individual totaled almost 900 miles in a little over 3 months (Ladd 2013b). Another male tagged in 2010 traversed the Missouri and Platte Rivers, covering more than 1,200 river miles spanning across four states (Chojnacki and DeLonay 2014).

Spawning is reported to occur between June and August, (Kallemeyn 1983) while others has indicated that fish in northern latitudes may spawn from March through July. In addition to being long-lived, females may not spawn every year. A lack of recruitment to the population of spawning-aged fish has been noted since the 1990 listing petition. In particular, although pallid sturgeon appear to be spawning, evidence suggests little, if any, pallid sturgeon recruitment has occurred (Steffensen et al., 2014), threatening the continued existence of the species (USFWS 2014). Knowledge of pallid sturgeon reproduction and spawning behavior, such as microhabitat characteristics of spawning locations, substrate preference, water temperature, and spawning timing, has been rapidly increasing. Because most of the current research has been conducted in the context of a highly-altered river, results of recent studies reflect which habitats are currently available and used by the pallid sturgeon for spawning.

The USFWS summarized available literature regarding pallid sturgeon in their 2000 BiOp. Pallid sturgeon are most frequently caught over a sand bottom, which is the predominant bottom substrate within the species' range on the Missouri and Mississippi Rivers. Constant et al. (1997) noted that pallid sturgeon spent considerable time associated with sand substrates. They noted that preference for sand substrates in low-slope areas suggests that pallid sturgeon use such areas as current refugia (e.g., use sand-wave troughs created as bed material moves along the river bottom. The pallid sturgeon collected on the Yellowstone River in July 1991 by Watson and Stewart (1991) was over a bottom of mainly gravel and rock, which is the predominant substrate at that capture site. Reed and Ewing (1993) found sturgeon occurring in the man-made, rip-rap lined outfall channels of the Old River Control Complex in Louisiana. Bramblett (1996) found that pallid sturgeon preferred sandy substrates, particularly sand dunes, and avoided substrates of gravel and cobble. Pallid sturgeon have adhesive eggs. Thus, spawning is thought to occur over hard substrates of gravel or cobble with moderate flow.

Spawning activity appears to be driven by several environmental stimuli, including length of day, water temperature, and flow regime (USGS 2007, DeLonay et al. 2009). Pallid sturgeon have adhesive eggs; spawning usually occurs adjacent to or over course substrate (e.g., boulders, cobble, gravel) or bedrock and in deep water with relatively fast, converging flows. Incubation rates are dependent on water temperature, but eggs hatch in 5–7 days under hatchery conditions (Keenlyne 1995). Incubation rates may differ slightly in the wild compared to hatchery conditions (USFWS 2014). Fecundity appears to be related to body size: the largest pallid sturgeon produce as many as 150,000–170,000 eggs (Keenlyne et al. 1992, USFWS 2014), and smaller females may only produce 43,000–58,000 eggs (George et al. 2012).

Intensive tracking of reproductive adult pallid sturgeon has been conducted through the CSRP. Two wild pallid females were tracked to apices of their migration in 2007; when subsequently recaptured, they were determined to have finished spawning. This study was the first to document spawning of pallid sturgeon in the LOMR. In 2008, three separate pallid sturgeon spawning patches were resolved to areas of several hundreds of square meters by intensive tracking of three gravid female pallid sturgeon of hatchery origin. Each of the three geographically separated patches was on the outside of a revetted bend, with deep, relatively fast, and turbulent flow (DeLonay et al. 2010). Similar results to those observed in 2008 were observed in 2009, when it was documented that spawning occurred in deep (>3 meters), swift water (>1 m/s) over or adjacent to course substrate along the base of a revetted outside bend (DeLonay et al. 2010).

Embryos and post-hatch larvae are free drifting downstream from their spawning location. The transition to the exogenous feeding larval stage (fry that have absorbed their yolk and are actively feeding) approximately coincides with the transition to the utilization of benthic habitats 11–17 days post-hatch, after which the majority (63-89 percent) of larvae have been found in the lower 0.5 m of the water column (Braaten et al. 2008).

The average larval pallid sturgeon may drift 245 to 530 kilometers (152–330 miles) in the first few weeks of life (Braaten et al. 2008). Recently, Jacobson et al. (2015) and USACE (2014) describe the development and application of 1-dimensional models to address rates of larval drift (i.e., advection, dispersion) in the upper and lower portions of the Missouri River. The results of these models are discussed in detail in Section 4.1.4.3 (Entrainment). In their early life history stages, pallid sturgeon are weak swimmers and are very small (yolk sac larvae and early exogenous feeding larvae are <40 mm; Rapp 2014), making them vulnerable to predation and entrainment. Their vertical position in the water column may be a behavioral trait that results in reduced predation by providing cover in deeper and darker areas (Guy et al. 2015, Guy pers. comm.).

Results from the CSRP support the hypothesis that spawning location, water velocities, growth rates, and drift dynamics determine the spatial and temporal distribution of pallid sturgeon larvae and juveniles in the Missouri River (DeLonay et al. 2010). Calculations based on mean reach velocities indicate that drifting larvae that hatch along much of the LOMR have the potential to drift into the Mississippi River. The authors emphasize that habitat restoration that facilitates spawning farther upstream, increases river length (by restoring cut-off channels), or decreases larval drift distance may assist in recruiting Scaphirhynchus sturgeon in the Missouri River. Improved understanding of typical drift distances of larval Scaphirhynchus sturgeon may provide useful guidance for placement of channel-restoration projects intended to provide rearing habitat. Whether larval sturgeon habitat is limiting for survival of larval sturgeon has not yet been determined. However, DeLonay et al. (2010) consider their results to indicate that spawning habitat availability is not a limiting factor in pallid sturgeon reproduction in the LOMR.

From repeated collections of larval sturgeon in the Middle Mississippi River, Hrabik (2002) surmised that sturgeon (shovelnose and pallid) are spawning at the head of islands or other locations upstream and being transported as larvae to eddy pools along island shores and to the downstream tips of islands that may provide refugia for the developing fish. Doyle and Starostka (2003, reported in USFWS 2003) found juvenile sturgeon to be strongly associated with main channel sand bars over sand substrate and were caught throughout the range of velocities sampled. They collected young of the year (YOY) juvenile sturgeon and pallid sturgeon with trawls on sand bars, island tips, and notched L dikes. The YOY sturgeon were found along channel sand bars, as well as behind notched dikes with moderate flows. The authors suggest that there appears to be a preference for habitat created by dike modifications or islands that is used by pallid sturgeon, lake sturgeon, and shovelnose sturgeon during early life stages (Doyle and Starostka 2003, reported in USFWS 2003).

Six genetically-confirmed larval pallid sturgeon have been identified in laboratory analysis' conducted as part of the 2014 Missouri River field sampling efforts. Three of the individuals were collected upstream of the Platte River (Nebraska) and were estimated to be 1-2 days of age. The other three individuals were larger in size and had exited the drift stage. One individual, captured on June 5, 2014 was 20 millimeters (mm) and captured near Missouri River Mile (MRM) 321. The remaining individuals were 24 and 48 mm and captured near MRM 10 on June 11 and 23, 2014, respectively (Gemeinhardt pers. comm. 2015). Even though this is important information that aligns with most current literature regarding larval drift and distribution, much more investigation is needed to draw definitive conclusions regarding the physical attributes and hydraulic conditions that lead to the interception and retention of age-0 sturgeon in the LOMR. These pallid sturgeon captures have occurred amongst several thousand larval shovelnose sturgeon captures, suggesting that larvae and young of year of these species utilize habitat features in the LOMR in similar ways (Gemeinhardt per comm. 2015).

4.1.3.4 Diet

Much of the dietary research on pallid sturgeon has been completed in conjunction with research on the food consumption of the closely related shovelnose sturgeon. These studies show that the majority of both these species' diets are comprised of aquatic insects, although pallid sturgeon generally consume more fish than the shovelnose sturgeon (Carlson et al. 1985). These findings suggest that the pallid sturgeon occupy a higher trophic level than the shovelnose, which may help explain the greater decline in their population (Gerrity, Guy, and Gardner 2006).

Food items consumed by pallid sturgeon range from aquatic insects to fish depending on life stage (Gerrity dt al. 2005,; Gerrity et al. 2006; Wanner 2006, Hoover, George, and Killgore 2007). It is believed that pallid sturgeon are opportunistic suctorial feeders on benthic organisms (Held 1969, Carlson et al. 1985, Keenlyne 1997). During the larval stage, pallid sturgeon begin as endogenous feeders, relying on their yolk sac for food. As sub-adults they develop an exogenous feeding ability and begin to eat zooplankton, however, it is hypothesized they rapidly transition to a diet more laden with chronimids. In a hatchery environment, exogenously feeding fry will consume brine shrimp, suggesting that zooplankton and small invertebrates are likely the food base for this age group (Hoover, George, and Killgore 2007).

The lack of a mixed feeding period may render pallid sturgeon larvae vulnerable to starvation if appropriate prey is not available as they make their physiological transition to exogenous feeding (Rapp 2012). This is an important co-factor when considered alongside larval drift patterns. Once larval drift ceases, larval pallid sturgeon are immediately dependent on quality and quantity of exogenous prey. This highlights the importance of quality nursery habitats within the drift distance of pallid sturgeon (Rapp 2012). Pallid sturgeon diet is generally composed of fish and aquatic insect larvae, suggesting that pallid sturgeon may be omnivorous with a preference for piscivory as the fish reach larger sizes.

4.1.4 Threats

Recently the USFWS released an updated recovery plan for the pallid sturgeon (USFWS 2014). The recovery plan synthesized species history, present status of the population, threats leading to listing, recovery actions, and recovery strategies. Threats identified in the recovery plan include the following:

- Habitat alteration
- Water quality
- Entrainment
- Climate change
- Overutilization
- Disease or predation
- Inadequacy of existing regulatory mechanisms
- Effects of new energy development
- Hybridization with shovelnose sturgeon
- Invasive species

4.1.4.1 Habitat Alteration

Historically, the Missouri River was a dynamic system composed of multiple channels, chutes, sloughs, backwaters, side channels, and migrating islands and sandbars. Over time, the river has been altered to improve navigation and reduce flooding. The most obvious changes to the river were the installation of dams in the Upper Missouri River and channelization of the LOMR. These changes have resulted in dramatic alterations to pallid sturgeon habitat over the past century. Approximately 51 percent of the pallid sturgeon's historical range has been affected to some degree by channelization. Approximately 28 percent of historical habitat has been impounded; 21 percent is affected by upstream impoundments that alter flow regimes, depress turbidity and water temperatures, with continuing bank stabilization activities that limit channel meandering (Keenlyne 1989, USFWS 2000). These modifications to the river may restrict the life cycle requirements of pallid sturgeon by blocking movements to spawning and feeding areas, affecting genetic exchange among reaches (i.e., reducing or eliminating emigration and immigration), decreasing turbidity levels by trapping sediment in reservoirs, reducing larval drift distances, altering conditions and flows of potential remaining spawning areas, and reducing food sources by lowering productivity (Hesse et al. 1989, Keenlyne 1989, USFWS 2000, Bowen et al. 2003). In the Upper Missouri River, there are indications that bottom-oriented larval drift into hypoxic reservoir zones may be responsible for high mortality of newly-hatched sturgeon (Braaten et al. 2012, Guy 2015). However, the Action Area for this project is entirely downstream of these reservoirs.

The Missouri River downstream of Gavins Point Dam is unimpeded by dams and is biologically and hydrologically connected with the Mississippi River. However, both unchannelized and channelized reaches are highly affected by anthropogenic modifications (USFWS 2014). Although the Missouri River downstream of Gavins Point Dam is not impounded, it is influenced by the operation of upstream dams. Additionally, nearly all major tributaries to this reach have one or more dams, which cumulatively affect flows and sediment transport. Damming and channelizing the Missouri River and tributaries adversely affects pallid sturgeon (USFWS 2000a, 2003). Sediment trapped behind upstream dams leads to decreased sediment transport and subsequent decreased turbidity in lower reaches, which may make larval pallid sturgeon in the lower reaches susceptible to predation, as discussed below in Section 4.1.4.7 Predation.

There have been concerns regarding the potential impacts of habitat alteration and channel changes on SWH enhancement projects, or on SWH in general. River bed degradation, in conjunction with the local (reach-scale) removal of sand and gravel, may affect the quantity and distribution of natural or created SWH in the LOMR. Potential effects on naturally occurring SWH could result from changes in elevation, configuration, or connectivity of the SWH to the main river channel, or could affect the performance of SWH projects relative to design specifications.

The proposed action may affect pallid sturgeon habitat in the action area. Potential effects are discussed further in Section 6.1 (Potential Effects to Pallid Sturgeon Habitat).

4.1.4.2 Water Quality

Pallid sturgeon may be affected by water quality issues throughout their range, including environmental contamination and pollution, low dissolved oxygen, and unstable temperature regimes.

To date, few studies have measured environmental contaminant concentration in pallid sturgeon. Tissue samples from three Missouri River and 13 Mississippi River pallid sturgeon contained metals (e.g., mercury, cadmium, and selenium), polychlorinated biphenyls (PCBs), and organochlorine pesticides (e.g., chlordane, dichloro-diphenyl-trichloroethane, and dieldrin) at concentrations of concern (Ruelle and Keenlyne 1993; Ruelle and Henry 1994).

Research involving white sturgeon (*Acipenser transmontanus*) in the Columbia River found lower condition factors, gonadal abnormalities, and hermaphrodism in fishes with elevated levels of metabolites of DDT (DDE and DDD) as well as total PCBs and mercury (Feist et al. 2005). Shovelnose sturgeon collected from the LOMR have exhibited both male and female gonad tissue (intersexual characteristics) (Wildhaber et al. 2005). Intersexual shovelnose sturgeon from the Middle Mississippi River had higher concentrations of organochlorine compounds when compared to male shovelnose sturgeon (Koch et al. 2006b). While the effects of contaminants specifically on pallid sturgeon reproduction are poorly understood, observations of pallid sturgeon that exhibited both male and female reproductive organs have been documented (DeLonay et al. 2009, USEPA 2010).

Another possible threat to pallid sturgeon is point-source discharge from wastewater treatment plants, which discharge hormonally active compounds and can cause endocrine disruption in sturgeon and other fish species (Purdom et al 1994, Routledge et al. 1998, Cheek et al. 2001, Schultz et al. 2003).

A basin-wide contaminants review for pallid sturgeon was initiated in 2008. To date, this investigation has identified pesticides, metals, organochlorines, hormonally active agents, and nutrients as contaminants of concern throughout the species' range.

Little is known about pallid sturgeon tolerances of low dissolved oxygen concentrations (hypoxia); therefore, information for surrogate species (e.g., shovelnose sturgeon) is used to gain insight. In general, sturgeon species are not as tolerant of hypoxic conditions as are other fishes. Early life stages are more susceptible than adults to changes in both temperature and dissolved oxygen levels, which affect survival, growth, and respiration (Secor and Gunderson 1998, Niklitschek and Secor 2005).

Larval pallid sturgeon are primarily benthic within 10–17 days post-hatch (Kallemeyn 1983, Kynard et al. 2007, Braaten 2008). The vertical distribution of pallid sturgeon larvae could make them more likely to encounter hypoxic conditions, which occur in both the upper and lower reaches of the Missouri River. Although juveniles and adults have some ability to avoid unfavorable environmental conditions via migration, larval pallid sturgeon are weak swimmers and cannot necessarily migrate away from unsuitable areas (USFWS 2014).

Anthropogenic changes within the range of pallid sturgeon that affect dissolved oxygen could be affecting survival and recruitment. As discussed above, both the Upper Missouri River and LOMR and their tributaries are significantly altered by impoundments and channelization. Dissolved oxygen conditions are unfavorable for larval pallid sturgeon in the Upper Missouri River due to the presence of reservoirs; however, levels in the un-impounded LOMR can also be low. Measurements on the LOMR from 2006 to 2009 showed that large rises in the river during spring and summer often coincide with dissolved oxygen levels in the water column falling to <2 milligrams per liter (mg/l) and remaining below 5 mg/l for several days (Blevins 2011). Dissolved oxygen levels of 3 mg/l along with water temperatures of 22–26°C (71.6–78.8°F) are lethal to juvenile Atlantic sturgeon, and reduced growth of these juveniles occurred at lower levels (6–7 mg/l) (Secor and Gunderson 1998, Campbell and Goodman 2004).

Water temperatures influence nearly every aspect of the pallid sturgeon life cycle. Temperature influences sexual maturity rates, spawning migrations commencement, gonad development, embryonic development rates, larval drift distances, and habitat quality (Keenlyne 1995, Kynard et al. 2002, USGS 2007, Braaten et al. 2008, DeLonay et al. 2009, Webb *in litt.* 2011 as cited in USFWS 2014).

Water released from upstream dams is substantially colder due to holding conditions in the reservoir behind the dam. When the water is released, it substantially cools the riverine environments downstream. The magnitude of the temperature effects decreases with increased distance from the dams; therefore, the upper reaches of the Missouri River are more affected by cold water releases than the lower reaches.

4.1.4.3 Entrainment

Entrainment is the direct removal of aquatic organisms from the water column by the suction field or flow field generated at intakes of facilities or hydraulic dredges (Reine and Clarke 1998) or inflow zone of boat propellers. In areas of operation, suction-based dredging has posed an entrainment risk to pallid sturgeon and other aquatic organisms. Quantification of pallid sturgeon loss associated from this action and water diversion structures has not been accurately described, although some modeling estimates have been developed by USACE based on flow field predications of cutter-head dredges (McNair and Banks 1986).

Preliminary data from non-dredging actions on the Missouri River suggest that entrainment may be a threat that warrants more investigation; most concerns are focused on early life stages (egg and larvae) that are subject to drift and incapable of avoidance. Initial results from work conducted by Mid-America at their Neal Smith power facilities found that hatchery-reared pallid sturgeon were being entrained

(Burns & McDonnell Engineering Company 2007a, 2007b). Over a 5-month period, four known hatchery-reared pallid sturgeon were entrained, of which two were released alive and two were found dead. The USACE, St. Louis District, and the Dredging Operations and Environmental Research (DOER) Program have initiated research to assess the entrainment of larval and juvenile pallid sturgeon during dredging (Hoover et al. 2005). Data for escape speed, station-holding ability, rheotaxis and response to noise, and dredge flow fields are being used to develop a risk assessment model for entrainment of sturgeon by dredges.

Larval drift is currently being modeled under varying hydrographic scenarios, and the results of these efforts may shed light on larval drift as a co-factor for entrainment. Jacobson et al. (2015) and USACE (2014) describe the development and application of 1-dimensional models (e.g., HEC-River Analysis System, or HEC-RAS) to address rates of larval drift (i.e., advection, dispersion) in the upper and lower portions of the Missouri River. The HEC-RAS was implemented using both steady and unsteady (i.e., seasonal hydrograph) flow scenarios. The model represents sturgeon larvae as a conservative tracer (i.e., an element that can be used to track flow) in simulating advection (i.e., the transfer of matter, in this case larval sturgeon) and dispersion over a wide area.

The model for the lower river was implemented from RM 800, just below Gavins Point Dam, to the confluence with the Mississippi River. The lower river was modeled using two separate, overlapping HEC-RAS models. The upper river model addressed the river from Gavins Point to the Rulo, Nebraska reach. The second model addressed the 498-mile river reach from Rulo to the confluence with the Mississippi River. Flows used to evaluate drift ranged from 31,500 to 458,000 cubic ft/s (USACE 2014). The model was calibrated using USGS flow and elevation data obtained from October 2007 – October 2013. The model was calibrated to be accurate +/- 1 foot for 81–93 percent for the model: data comparisons are within 2 feet of the measured values between 96 and 99 percent of the modeled period.

The 1-dimensional HEC-RAS simulates drifting larvae as neutrally buoyant particles, which might over-estimate rates of drift, given observations that the larvae are negatively buoyant and tend to drift at rates somewhat less than average river velocities. The model results for larvae introduced at RM 800 indicated advection rates that ranged from 40 to 85 miles/day, depending on location and river flow rates. Advection rates (i.e., the transfer of larval sturgeon) tend to increase downriver with changes in bedform and contributions of tributary flows. Modeled larvae introduced at RM 800 remained with the LOMR for 12–14 days before entering the Middle Mississippi River. Modeled larvae introduced at RM 600 (Platte River confluence) remained for 9–10 days under the same modeled flows. Larvae introduced at RM 400 (within the proposed dredging areas) drifted to the Mississippi River in approximately 6 days (USACE 2014). The model results could be used in combination with measures of the onset and location of spawning to define time periods within which larval entrainment by dredging would be anticipated. For example, if pallids spawn primarily during May, the resulting larvae should have drifted through the proposed dredging areas and be unavailable for entrainment by mid-June.

In addition, the USACE Engineer Research and Development Center (ERDC) has applied its more detailed Particle Tracking Model to simulate the likelihood of larval interception by side channels and chutes at the Hamburg Bend (USACE 2014). This effort was undertaken to address the assumptions inherent to the 1-dimensional HEC-RAS (e.g., vertically averaged flows and homogeneous distribution larvae in the water column). The Particle Tracking Model also was used to examine the efficacy of side-channel construction to increase the interception of drifting larvae. If such construction projects prove beneficial in moving drifting larvae from the thalweg, fewer larvae would be available for entrainment. However, this analysis is still ongoing and has been limited in application (i.e., Hamburg Bend).

Larval and juvenile pallid sturgeon entrainment is known to occur in the few instances it has been studied, and USFWS has expressed ongoing concern about the effects of entrainment in their 2014 Revised Recovery Plan despite the level of uncertainty with regards to the timing and number of pallid sturgeon entrained (USFWS 1993, 2014). Uncertainty remains as to how extensive the encounters are and what the variation is during various times of the year. More details on entrainment are provided in Section 6.

4.1.4.4 Climate Change

Although not a threat specifically identified in the pallid sturgeon listing package (55 FR 36641–36647), USFWS included a discussion of climate change in the analyses under the ESA (USFWS 2014). Various types of climate change can cause direct and indirect effects on species. In general, the trend in global climate is one of warming, with average temperatures in the United States at least 1.1°C (2°F) higher than they were 50 years ago (Intergovernmental Panel on Climate Change 2007, U.S. Global Change Research Program 2009). The effects of climate change would most likely be more pronounced in northern portions of the pallid sturgeon range.

The potential effects of climate change on pallid sturgeon are not only limited to the direct effects of increases in water temperature. Changes in historical patterns of regional precipitation associated with larger scale alterations in climate could produce substantial flooding (e.g., 2011 flood) or unanticipated periods of drought and associated low river flows throughout the Missouri River system. While it remains beyond the state of the science to accurately forecast climate-induced changes in regional hydrology, future deviations from historical patterns of seasonal flows (i.e., timing, magnitude, and duration) might pose risks to pallid sturgeon (e.g., loss of spawning or foraging habitats).

4.1.4.5 Overharvest

Overharvest for commercial, recreational, scientific, or educational purposes is one of the threats to pallid sturgeon identified in the species' listing determination. Following listing, Montana, North Dakota, South Dakota, Nebraska, and Iowa closed all commercial sturgeon fishing on the Missouri River.

The shovelnose and pallid sturgeon and their roe (eggs sold as caviar) are similar in appearance; thus, pallid sturgeon are vulnerable to lethal take as a result of species misidentification associated with commercial shovelnose sturgeon fishing. To address this threat, beginning in 2010, shovelnose sturgeon have been treated as threatened where the two sturgeon species coexist, under the similarity of appearance provisions of the ESA (75 FR 53598–53606). Current state regulations and ESA protection and enforcement appear adequate to manage the threat of pallid sturgeon overharvest (USFWS 2014).

As stated previously (Section 4.1.1), the shovelnose and pallid sturgeon and their roe are similar in appearance. Currently, there is no reliable and completely accurate way to visually or genetically discern among roe of the two species, making enforcement of existing closed fishery regulations difficult.

4.1.4.6 Disease

Fish pathogens include viral, bacterial, and parasitic agents. These pathogens have the potential to produce severe epizootics of clinical disease but also exist in a carrier state. Two pathogens of notable importance for pallid sturgeon recovery are Viral Hemorrhagic Septicemia Virus (VHSv)) and Missouri River Sturgeon Iridovirus (MRSIV), which is sometimes referred to as PSIV (Pallid Sturgeon Iridovirus).

VHSv is a viral fish disease that has caused large-scale mortalities in numerous fish species (Kim and Faisal 2010). This virus has a number of identified isolates grouped in four types; three are from Europe and one is from North America. Each appears to have unique effects with specific pathogenicity on certain species. While the virus has not been documented to affect pallid sturgeon, it also has not been found in the range of the species. However, VHSv has been documented in the Great Lakes, which are now connected to the Mississippi River via shipping canals (APHIS 2006). It is therefore possible that VHSv could become established in the Missouri River. Because this pathogen can cause large-scale mortalities in fish populations and has a wide range of potential carriers, it is critical to make every attempt to monitor pallid sturgeon for VHSv.

MRSIV is known to cause mortalities in hatchery-reared pallid sturgeon (USFWS 2006). MRSIV was first detected in shovelnose sturgeon at the Gavins Point National Fish Hatchery in 1999. This iridovirus is known to infect pallid and shovelnose sturgeon (Kurobe et al. 2011). Of 179 *Scaphirhynchus* tested from the Atchafalaya River between November 2003 and May 2004, eight (4 percent) were identified as virus positive and five (2.8 percent) were considered virus suspect. Subsequent testing with more sensitive methods also confirmed the presence of the virus in the wild (Hedrick et al. 2009), suggesting that it may be endemic to the Missouri River, but the effect of the virus on wild populations is poorly understood (USFWS 2006).

4.1.4.7 Predation

Predation on larval fishes of all species occurs naturally. However, habitat modifications and increased water clarity and elevated non-native and native predatory fish populations could result in increased rates of predation on pallid sturgeon.

Pallid sturgeon embryos, post-hatch larvae ("free embryos"), and larvae drift freely (Kynard et al. 2007, Braaten et al. 2008). This behavior exposes naturally-spawned pallid sturgeon to predation, which was moderated historically by high fecundity and turbid waters, Additionally, due to channelization, naturally–spawned pallid sturgeon embryos and larvae are likely transported longer distances than they would have been historically, which suggests a high rate of exposure to predation and a high likelihood of larvae being transported into the headwaters of reservoirs like Fort Peck and Lake Sakakawea where other factors, such as dissolved oxygen, are suboptimal. Larvae that enter the reservoirs are exposed to a more lentic environment, which may even have been artificially supplemented with predatory species like walleye (*Sander vitreus*). Maintaining elevated populations of certain species in these reservoirs has been hypothesized as a contributing factor in poor survival of larval and juvenile pallid sturgeon. Parken and Scarnecchia (2002) reported that walleye and sauger (*Sander canadensis*) in Lake Sakakawea, North Dakota were capable of eating wild paddlefish (*Polyodon spathula*) up to 6.6 inches (167 mm) body length (12 inches [305 mm] total length) and thus likely could consume naturally-produced pallid sturgeon larvae and smaller hatchery-produced pallid sturgeon released as part of supplementation efforts. When looking at these data for their sample location closest to the headwaters area, it appears that no age-0 paddlefish were found in walleye but were present in sauger, a native species closely related to walleye. Braaten and Fuller (2003, 2002) examined 759 stomachs from seven piscivorous species in Montana and found no evidence of predation on sturgeon. However, in all species sampled, unidentified fish or fish fragments were present. Hogberg and Pegg (2013) found sturgeon in the stomachs of flathead catfish (*Pylodictis olivaris*) during studies in the LOMR. Predation vulnerability of pallid sturgeon larger than 40 mm in size (1.6 inches) by channel catfish, smallmouth bass (*Micropterus dolomieu*), and walleye appears to be low, provided other prey species are available (French 2010, French et al. 2010). More data are needed to adequately assess predation effects on pallid sturgeon eggs and larvae in order to evaluate implications on recruitment success.

In the LOMR, decreased turbidity may be a factor in predation on early life stages of pallid sturgeon. The significantly decreased suspended sediment levels in the water due to reservoir and water management may not be providing the level of turbidity cover that could be a critical, if not limiting, factor for the success of early life history stages. However, no studies have evaluated this hypothesis.

4.1.4.8 Inadequacy of Existing Regulatory Mechanisms

Federal, state, and local regulatory protections have been developed to minimize and mitigate known and potential threats to pallid sturgeon and their habitats from anthropogenic activities. While some of these mechanisms have been helpful and benefitted the species (e.g., the Clean Water Act), recovery progress to date is the result of the ESA and its enforceable provisions to ensure conservation of listed species. Absent protections under the ESA, current state and federal regulations may be inadequate to ensure long-term protection for pallid sturgeon. Some of the inadequacy is due to the lack of specific scientific information on population size, habitat use, and sensitivity or vulnerability to contaminants, entrainments, and other threats (USFWS 2014).

4.1.4.9 Other Factors

4.1.4.9.1 Energy Development

Exploration of natural gas and oil deposits occurs in portions of the pallid sturgeon's range. Preliminary assessment of the impacts of seismic air guns used for exploration suggests that they may negatively affect larval sturgeon, but more research is needed to quantify the magnitude of the effects. Gas and oil pipelines also commonly intersect rivers within the range of pallid sturgeon. Ruptures of these pipelines could pose a significant risk to pallid sturgeon of all life stages in the future.

4.1.4.9.2 Hybridization with Shovelnose Sturgeon

Pallid sturgeon are known to hybridize with shovelnose sturgeon in the wild, and viable offspring have been produced in laboratory settings (Kuhajda et al. 2007). Since hybridization is occurring and likely has been occurring for many decades (Schrey et al. 2011), it is important to determine the cause (historical/natural or contemporary), extent, and frequency or rates of hybridization. Habitat alterations within the range of pallid sturgeon may have influenced temporal or spatial reproductive isolating mechanisms, resulting in increased rates of hybridization. More data are needed before conclusions can be generated.

4.1.4.9.3 Invasive Species

Several species with the potential to adversely affect pallid sturgeon have become established in parts of the species' range. These species include the Asian carps (common carp [Cyprinus carpio], grass carp [Ctenopharyngodon idella], silver carp [Hypophthalmichthys molitrix], bighead carp [Hypophthalmichthys nobilis], and black carp [Mylopharyngodon piceus]) and the zebra mussel (Dreissena polymorpha). Nearly all fish feed on zooplankton as larvae and juveniles; therefore, the introduction of highly–competitive non-native species could result in competition for food resources in addition to direct predation on eggs and juvenile sturgeon, exclusion of native fishes from preferred habitats, spread of diseases or parasites, and alteration of habitat quality. The consequences of invasive species have been well documented in other river systems, but further study is needed to fully quantify and qualify the magnitude of this probable threat to pallid sturgeon (USFWS 2014).

4.1.5 Management and Protection

In addition to the dredging exclusion areas (Table 3-4), the amended BiOp (USFWS 2003) provides suggestions for extensive pallid sturgeon protective and recovery measures. The amended BiOp calls for restoration of a portion of the shallow water aquatic habitat lost from river engineering. Shallow-water habitat (SWH) on the LMOR is defined by the USFWS as water less than 5 feet (1.524 m) deep with a current velocity less than 2.5 feet per second (0.762 m/s), and is thought to be important for rearing of larval and juvenile pallid sturgeon (USACE 2004a). The BiOp also requires restoration of nearly 20,000 acres of SWH by 2020 and allows this habitat to substitute for achievement of SWH by variety of mechanisms, including excavation of side-channel chutes, dike notching, bank notching, and construction of chevrons.

As described previously (Section 4.1.3.2 Shallow Water Habitat), SWH projects in the main channel have been monitored under the HAMP since 2004. The main findings to date are that fish use of SWH is highly variable in project and control reaches (Sampson and Hall 2009 as cited in NAS 2010). Gemeinhardt et al. (2015) investigated the relationships between the prevalence of SWH (defined in that study as <1.5-meter depth) and catch rates of age-0 sturgeon (shovelnose and pallid) in the LOMR. Results of that study found no relationship between age-0 sturgeon mean catch-per-unit-effort and hectares/kilometers of SWH.Reasonable and Prudent Alternatives are also described in the amended BiOp, with direct intent of pallid sturgeon species and habitat recovery. Achieving naturalization of the flow regime is a main goal of these efforts, with the intent to address (1) connection of the main channel to the flood plain seasonally for nutrient and energy exchange and fish access to floodplain habitats; (2) maintenance of nursery habitat for larval and juvenile pallid sturgeon (meeting essential late summer flows); (3) providing environmental spawning cues for the pallid sturgeon through some combination of discharge and discharge-related variables like temperature, turbidity, and velocity; and (4) providing access to spawning habitat or "conditioning" of pallid sturgeon spawning habitat by flushing fine sediment from coarse substrate.

4.1.6 Status of Pallid Sturgeon in the Action Area

Originally, the *Pallid Sturgeon (Scaphirhynchus albus) Recovery Plan* (USFWS 1993) identified six Recovery Priority Management Areas (RPMAs) for implementation of recovery tasks based on the most recent pallid sturgeon records of occurrence and the potential of these areas to contribute to the recovery of the species. Since that time, improved understanding of the species has warranted redefining the management areas into four management units (Figure 4-6). These management units are based on genetic data, morphological differences, biogeography of other fish species and speciation associated with physiographic provinces, common threats, and potential need and ability to implement differing management actions to address threats. As genetic and stock structure data are further refined, these management units may be correspondingly adjusted. Each management area possesses riverine reaches that are currently occupied habitats and typically represent the least degraded areas that retain the highest configuration of sandbars, side channels, and varied depths (Pallid Sturgeon Recovery Team 2006 and 2007).

The Action Area falls within the Interior Highlands Management Unit, which is defined as the Missouri River from the confluence of the Grand River to the confluence of the Mississippi River, as well as the Mississippi River from Keokuk, Iowa to the confluence of the Ohio and Mississippi Rivers (USFWS 2014).

The distribution of the pallid sturgeon in Missouri, Kansas, and Nebraska is restricted to the LOMR mainstem, with some limited use of the downstream portions of some large tributaries. Since 1994, pallid sturgeon populations have been augmented with hatchery-reared fish (USFWS 2007a). Pallid sturgeon stocking data between 1994 and 2009 are presented in Table 3.10-2 and illustrated in Figure 3.10-1 of the FEIS (USACE 2011). The collection of individuals from all stocked cohorts indicates that hatchery supplementation is contributing to the pallid sturgeon population in RPMA 4.

Between 1999 and 2005, 156 pallid sturgeon were captured in RPMA 4. Wild fish comprised 51 of the captured fish, while 82 captured fish were of hatchery origin and 24 fish were of unknown origin (USFWS 2007a). USACE sampling from 2003 to 2014 showed the capture of 4,007 hatchery-reared pallid sturgeon, 431 presumed wild fish, and 395 fish of unknown origin; a total of 4,833 pallid sturgeon captures have been recorded in the Missouri River below Gavins Point Dam through USACE monitoring efforts (Welker pers. comm.).

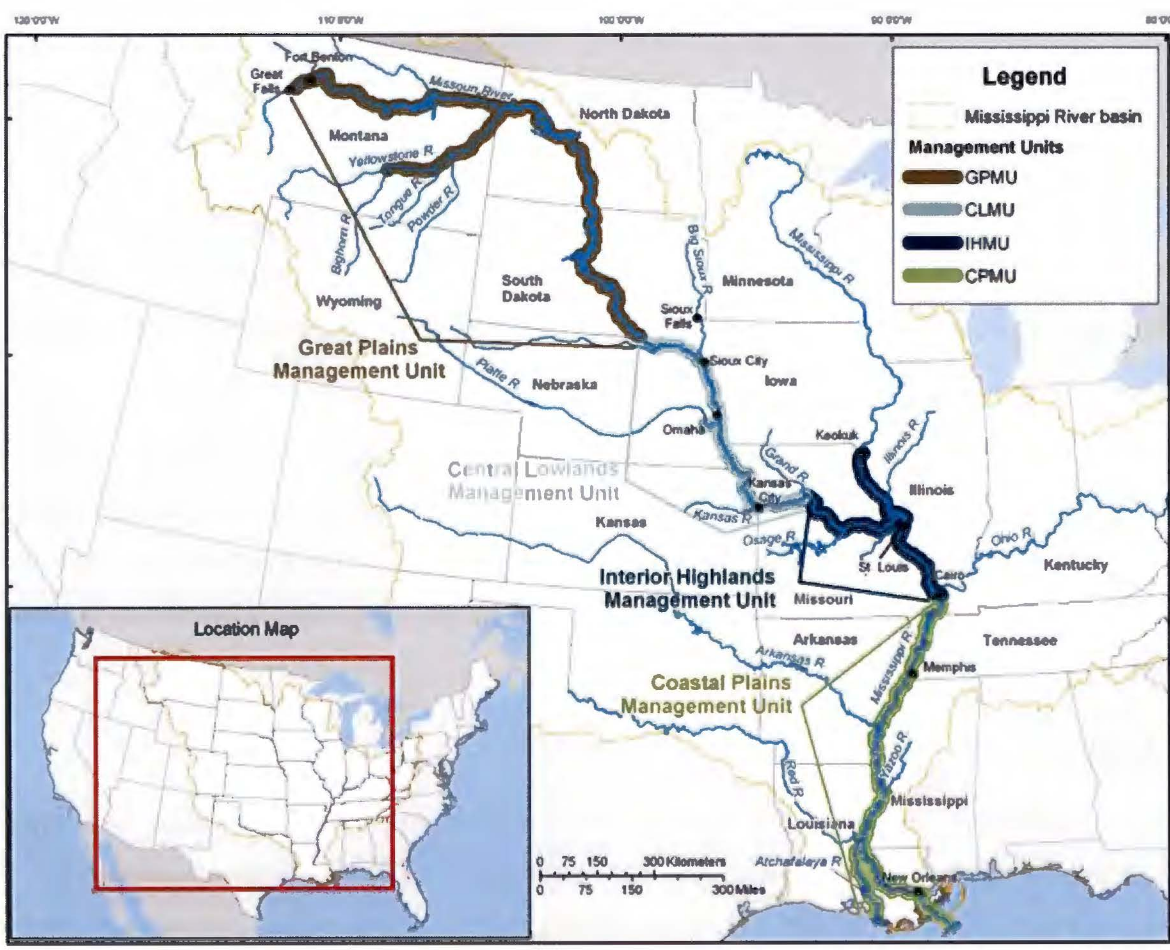

Figure 4-6 USFWS (2014) Pallid Sturgeon Revised Recovery Plan Management Units

4.2 PIPING PLOVER

4.2.1 Description

The piping plover (*Charadrius melodus*) is a small migratory shorebird. Throughout the year, adults have a sand-colored upper body, white undersides, and orange legs. During the breeding season, adults develop orange bills and single black bands on the forehead and breast (USFWS 2001, 2000). Males and females are similar in appearance, but the male is slightly larger and the base of its bill is a brighter orange during breeding season. Juvenile plumage is similar to adult nonbreeding plumage, and this species acquires adult plumage the spring after it fledges (Prater, Marchant, and Vuorinen 1977).

The piping plover is a migratory species that is recognized to have distinct interior and coastal populations. The interior populations include the Great Lake–Big Rivers population and those that occur in the Great Plains region.

4.2.2 Status

The piping plover (*Charadrius melodus*) was federally listed on December 11, 1985 (50 FR, 50726-50734) (USFWS 1994). The populations in the Great Lakes–Big Rivers region, which does not include the Action Area, are listed as endangered. Piping plover populations outside of this region are listed as threatened. The state of Missouri considers the piping plover a transient species in Missouri.

The USFWS has designated critical habitat for this species in the Northern Great Plains region, which includes portions of Nebraska (50 FR 67 57638–57717). Critical habitat in Nebraska is outside of the Action Area. Kansas has designated critical habitat for piping plover on the Kansas River, from the confluence of the Smoky Hill River and Republican River downstream to the confluence of the Kansas and Missouri Rivers in Kansas City, Missouri (KDWP 2009).

4.2.3 Threats

The creation of reservoirs, channelization of rivers, and modifications of river flows have eliminated hundreds of miles of piping plover sandbar nesting habitat (USFWS 1994). Eggs and young are vulnerable to predation and human disturbance, including recreational activities and off-road vehicle use. Recreational effects include vehicular and pedestrian traffic on suitable nesting sites where eggs are well camouflaged within the sand.

Human-caused disturbance to wintering habitats is also a threat to the continued existence of this species. Motorized and pedestrian recreational activities, shoreline stabilization projects, navigation projects, and development can degrade and eliminate suitable wintering habitat for the species.

4.2.4 Reproduction and Development

The piping plover returns to its breeding grounds in mid-April, and most birds have arrived in the Northern Great Plains and initiate breeding behavior by mid-May (USFWS 1994). Populations that nest on the Missouri, Platte, Niobrara, and other rivers use beaches and dry barren sandbars with less than 25 percent vegetation cover in wide, open channel beds (USFWS 1994). Nesting piping plovers have been found in least tern nesting colonies at a number of sites on river sandbars and sand pits in the Great Plains (USFWS 1994).

The nest is typically far from cover and consists of shallow scrapes in the sand lined with small pebbles or shell fragments. Egg laying commences by the second or third week in May. The female generally chooses from several nest sites the male has constructed. Complete clutches contain three to four cryptically colored eggs (USFWS 1994), and incubation is shared by the male and female for an average of 26 days. Brooding duties also are shared by the male and female. Broods remain in nesting territories until they mature unless they are disturbed. Fledging takes approximately 21 to 35 days (USFWS 1994). If a nest fails or is destroyed, adults may re-nest up to four times (USFWS 1987). Breeding adults begin leaving nesting grounds as early as mid-July, with the majority gone by the end of August (Wiens 1986).

4.2.5 Diet

The piping plover feeds by alternating running and pausing to probe the sand and mud for prey items in or near shallow water (Bent 1929). Prey consists of marine worms, fly larvae, beetles, insects, crustaceans, mollusks, and other small invertebrates. In North and South Dakota reaches of the Missouri River, Le Fer, Frasera, and Krusec (2008) found that foraging adult plovers selected protected shoreline (inter-sandbar channels, inlets, and backwater areas) more often than expected based on availability. They suggest that these saturated and moist habitats typically supported higher numbers of macroinvertebrates, providing good food sources for chicks. The implication for these findings in the LOMR is that ongoing efforts to restore backwater and diverse habitats for fishery resources could eventually establish a habitat that provides a prey base for the piping plover.

4.2.6 Range

Historically, the piping plover bred in three geographic regions: the U.S. and Canadian Northern Great Plains from Alberta to Manitoba south to Nebraska, the Great Lakes beaches, and the Atlantic coastal beaches from Newfoundland to North Carolina (USFWS 1988a). The species current breeding range is similar except that breeding populations in the Great Lakes have almost disappeared (Haig and Plissner 1993).

Wintering areas are not well known, although wintering birds have been most often seen along the Gulf of Mexico, southern U.S. Atlantic coastal beaches from North Carolina to Florida, eastern Mexico, and scattered Caribbean Islands (Haig 1986, USFWS 1988a).

The distribution of piping plover in the Great Plains region includes several of the major river systems, reservoirs, and other suitable shoreline and wetland habitat. In Missouri, they are considered a transient species that rarely occur during migration (The Audubon Society of Missouri 2009). The Missouri River contains up to 70 percent of the Northern Great Plains population (USFWS 2009c), but the piping plover does not breed within the confined channels of the Action Area. In the LOMR, aquatic restoration techniques to create emergent sandbar habitat (ESH) and techniques that promote deposition areas could eventually provide suitable breeding habitat.

4.2.7 Population Level

The number of adult plovers on the Missouri River system has fluctuated from a low of 86 in 1997 to a high of 1,764 in 2005 and appears to be roughly correlated with the amount of suitable habitat available on the Missouri River system (USFWS 2009c). Since 2005, the number of breeding pairs has fluctuated below the 1988 recovery plan goal for the Great Lakes and Great Plains of 465 pairs (USFWS 1988a).

The main reason given for the population fluctuations is the availability of suitable habitat. The LOMR experienced high flows between 1996 and 1997, after which the Missouri River basin underwent a drought. During the drought period, the amount of water storage declined from 71.7 million acre feet (MAF) in 1997 to 33.9 MAF in 2007 (USFWS 2009c); the exposed reservoir shoreline habitat led to large numbers of plovers successfully nesting on the shores of the reservoirs. For example, on Lake Oahe from 1994 through 1997, there was an average of 42 adult piping plovers, whereas from 1998 through 2008, there was an average of 235 adults (USFWS 2000).

The current estimated population size of the Northern Great Plains piping plover has increased in this decade but remains below the recovery goals set out in the 1988 recovery plan.

4.2.8 Habitat

Piping plovers use wide, flat, open, unvegetated sand or pebble beaches on shorelines, islands in freshwater and saline wetlands, or mid-channel or channel margin sandbars laid down by high river flows. Vegetation, if present at all, consists of sparse, scattered clumps (Montana Field Guide 2010). In the Northern Great Plains, most piping plovers nest on the unvegetated shorelines of alkali lakes, reservoirs, or river sandbars (USFWS 1988a); and nesting territories often include small creeks or wetlands (USFWS 2001). On occasion, however, these birds will select non-typical sites for nesting, such as on the Missouri River where piping plovers have been documented to nest among cottonwood seedlings in habitat previously thought too densely vegetated for plovers (McGowan et al. 2007).

Critical habitat has been designated for the Northern Great Plains population of piping plover, which is outside of the Action Area.

4.2.9 Management and Protection

Recovery plans are available for the Atlantic Coast and Great Lakes populations of piping plovers but not for the Great Plains region. Recovery efforts in these areas include conserving breeding and wintering habitat; and protecting breeding birds, eggs, and chicks from predators and from disturbance and death caused by human activities.

In 2000, the USFWS issued a BiOp for the USACE's management of the Missouri River that included Reasonable and Prudent Alternatives to avoid jeopardy to the piping plover (USFWS 2000). The BiOp required flow changes to provide plover habitat over time but was not implemented. In 2003, the USFWS amended the BiOp to allow the USACE to provide sandbar habitat for plover nesting by mechanically building sandbars (through dredging in the river to pile up sand material), clearing existing sandbars of vegetation, and flow modifications (USFWS 2003).

The 2003 BiOp requires a total amount of acreage that must be available for habitat and allows multiple means of meeting these targets. However, only minimal sandbar habitat is available under current river management operations and, in 2005, far fewer acres were available than required by the 2003 BiOp (USFWS 2009c). To address this shortcoming, since 2004, the USACE has constructed approximately 605 acres of sandbar habitat at seven different river locations. Five of these habitat areas were created in the reach below Gavins Point Dam, with two additional islands created above the dam in the headwaters of Lewis and Clark Lake.

Currently, the USACE manages both flood control and piping plover habitat on the Missouri River system, meaning that piping plover habitat is frequently flooded during the nesting season to provide for other authorized system purposes (e.g., navigation and flood control). The USACE must often choose between inundating shoreline nests in a rising reservoir or releasing water from the dam and inundating habitat downstream (USFWS 2009c). Whenever possible, the USACE regulates the system to reduce potential flooding of tern and plover nests on the Missouri River. River stages downstream of four of the mainstem dams are closely monitored, and releases are adjusted during the nesting season to prevent nest inundation when possible (USFWS 2000). Releases from Gavins Point Dam may be increased in early May, in time for the arrival of nesting plovers, to force the birds to nest on higher sandbars so that navigation target flows can be met later in the nesting season when downstream tributary flows begin their normal decline in July and August (USFWS 2000). However, even with some system modifications, competing multipurpose demands (e.g., navigation and flood control) may conflict with uniform or constrained peaking summer releases for plovers in downstream areas; and habitat along the Missouri River is often flooded during the breeding season (USFWS 2009c).

To reduce operational conflicts between protecting piping plover habitat and other system purposes, the USACE has tried to develop suitable plover nesting habitat at higher elevations; this has been successful in attracting nesting birds, but initial productivity was limited because of predation and lack of forage (USFWS 2009c).

The USACE has also developed an extensive monitoring and management program for piping plovers on the Missouri River system since 1986, predator aversion techniques, public outreach, habitat enhancements, and a captive rearing program. Monitoring work includes annually locating and mapping colony and nest site locations, conducting systematic breeding pair surveys, determining nest fates and fledge ratios, and evaluating annual habitat trends. Predator aversion has included the use of nest enclosure cages, strobe lights, electric barrier fences, and removal of local problem predators. Additionally, nesting sites with historical propensities for human disturbance are posted with restricted access signs and roped off to prevent nest and chick losses. Public outreach serves to educate people about piping plovers and the efforts being made to protect them. Outreach includes local interpretive programs, school presentations, brochures, radio and television spots, boat ramp interpretive signs, and video documentaries. Habitat enhancement projects include removal of vegetation through hand-pulling, herbicide applications, mowing, burning, tilling, disking, capping with gravel, blasting, and scouring with heavy equipment to prolong the suitability of existing sandbars. In 1995, the USACE began a piping plover captive rearing program, which resulted in the construction of state-of-the-art facilities.

4.3 INTERIOR LEAST TERN

4.3.1 Description

The interior least tern (*Sternula antillarum,* formerly *Sterna antillarum*) is the smallest North American tern (Thompson et al. 1997). It has a black crown on the head, a snowy whiter underside and forehead, grayish back and wings, orange legs, and a yellow bill with a black tip (USFWS 2009b). Males and females are similar in appearance.

Three subspecies of least tern are recognized in the United States: the eastern or coastal least tern (*Sterna antillarum antillarum*), the California least tern (*Sterna antillarum browni*), and the interior least tern (*Sterna antillarum athalassos*). The subspecies are identical in appearance and are segregated on the basis of separate breeding ranges. The interior population occurs along major rivers in the interior United States, including the Missouri, Mississippi Arkansas, Red, and Rio Grande River systems.

The interior least tern is primarily piscivorous, feeding mostly on small-bodied fish found in shallow freshwater and saltwater, but its diet is varied and it may occasionally take aquatic invertebrates (Thompson et al. 1997). These birds are opportunistic and tend to select any small fish within a certain size range. Least terns feed in shallow waters of rivers, reservoirs, and lakes and forage by hovering and diving into water to catch small fish and aquatic crustaceans (USFWS 2009b, 1990b) and occasionally skimming the water surface for insects.

4.3.2 Status

The interior population of least tern was federally listed as endangered on June 27, 1985 (50 FR 21,784-21,792) (USFWS 1990b). The least tern is also listed as a state endangered species by Missouri, Kansas, and Nebraska. The USFWS has not designated critical habitat for this species. The State of Kansas has designated critical habitat for the interior least tern on the Kansas River, from the confluence with the Missouri River to the limit of the Action Area 5 miles upstream. No critical habitat is designated within the Action Area.

4.3.3 Threats

Alteration and destruction of riverine habitats due to channelization; irrigation; and construction of reservoirs, pools, and dams since the 1940s have contributed to the decline of the species through the elimination of much of the tern's sandbar nesting habitat in the Missouri, Arkansas, and Red River systems (USFWS 1990b, Audubon n.d.). These types of disturbances can eliminate nesting sites, can disrupt nesting birds, or may result in sandbars that are unsuitable for nesting due to vegetation encroachment or frequent inundation. The wide channels with sandbars that are preferred by the terns have been replaced by narrow, forested river corridors (USFWS 2009b).

Further population declines in the 1950s to 1970s have been attributed to pesticide use and human disturbance of nesting habitats (Audubon n.d.). Recreational activities on rivers and sandbars can disturb nesting terns and cause the birds to abandon nests (USFWS 2009b).

Historically, fairly predictable summer flow periods consisted of a high flow in May and June and a decline in flow for the remainder of the summer. The decline in flow levels allowed interior least terns to nest as water levels dropped and sandbars became available (Texas Parks and Wildlife 2009). The current regulation of river flow regimes using dams can result in high flow periods extending into the normal nesting period or occurring after nesting has begun, thus flooding active nest sites (USFWS 1990b).

Recreational, industrial, and residential development in coastal breeding areas continues to diminish many populations (Audubon n.d.).

4.3.4 Reproduction and Development

Interior least terns arrive at breeding areas from late April to early June and spend from 4 to 5 months at the breeding sites. Least terns are considered colonial nesters; colonies typically consist of up to 20 nests although colonies with up to 75 nests have been recorded on the Mississippi River (USFWS 1990b). Upon arrival, adult terns usually spend from 2 to 3 weeks in noisy courtship, including finding a mate, selecting a nest site, and strengthening the pair bond.

Interior least terns arrive at breeding areas from late April to early June. Nesting areas of interior least terns include sparsely vegetated sand and gravel bars within a wide, unobstructed river channel or salt flats along lake shorelines (Nelson 1998, USFWS 1990b). Nesting locations are usually well above the water's edge because nesting is typically initiated during high river flows, when much of the bars and shorelines are flooded. The extent of available nesting area depends on water levels and the resulting amount of exposed bar and shoreline habitat. The interior least tern also nests on artificial habitats such as sand and gravel pits next to large river systems and dredge islands (Campbell 2003, USFWS 1990b).

Least terns nest on the ground in a shallow depression in an open sandy area, gravelly patch, or exposed flat. Small twigs, pieces of wood, small stones, or other debris usually occur near the nest. Usually two to three eggs are laid by late May, and both parents incubate the eggs for approximately 20–22 days (USFWS 1990b). The chicks leave the nest only a few days after hatching, but the adults continue to provide care by leading the chicks to shelter in nearby grasses and bringing food (USFWS 2009b). Fledging occurs within 3 weeks after hatching.

4.3.5 Range

The interior population of least tern is migratory, breeding along inland river systems in the United States and wintering along the Gulf Coast, the coast of Caribbean Islands, the eastern coast of Central America, and northern South America (USFWS 1990b).

Historically, the breeding range of the interior least tern population extended from Texas to Montana and included the Rio Grande, Red, Missouri, Arkansas, Mississippi, and Ohio River systems. The birds continue to breed in most of the historical river systems, although current distribution is restricted to less altered river segments (USFWS 1990b).

A 2005 breeding bird survey (Lott 2006) did not identify any least tern nest sites in Missouri, and no nest sites were observed on the Missouri River south of the confluence of the Lower Platte River in Nebraska. In Kansas, the distribution of least terns include the Kansas River, the Arkansas River system, the Platte River and its tributaries, the Missouri River and reservoirs upstream of Gavin's Point Dam, and several other locations in northern Nebraska.

4.3.6 Population Level

The least tern is a difficult species to census accurately because the species frequently shifts nesting sites and the timing of nesting varies locally because of weather, habitat availability, and latitude (Thompson et al. 1997). The 1990 recovery plan for the interior population of least tern estimated the population to be approximately 5,000 individuals (USFWS 1990b).

The overall recovery objective of 7,000 birds identified in the 1990 recovery plan has been met, but the mean number of least terns in all drainage basins identified in the plan has not reached corresponding objectives related to geographic distribution of those birds, nor has each area remained stable for 10 years, as called for in the recovery plan (USFWS 2003).

A 2005 breeding distribution survey identified that, although least tern populations occurred over much of the species' historical range, populations were limited to river reaches with suitable habitat. Least tern nests were primarily observed on suitable nest sites along rivers and reservoir shorelines. Colonies were also identified at sand pits, at industrial sites, on alkali flats, and on rooftops. The 2005 breeding bird survey identified a total of 17,591 individuals (Lott 2006).

4.3.7 Habitat

Interior least terns prefer open habitat and tend to avoid thick vegetation and narrow beaches. Nesting habitat for these birds includes barren to sparsely vegetated sand, shell, and gravel beaches, sandbars, islands, and salt flats associated with rivers and reservoirs (USFWS 2009b). Nesting locations are often in higher elevations away from the water's edge because nesting typically begins when river levels are high and relatively small amounts of sand are exposed (Texas Parks and Wildlife 2009). Least terns are highly adapted to nesting in disturbed sites and may move colony sites annually, depending on landscape disturbance and vegetation growth at established colonies. As natural nesting sites have become scarce, terns have used sand and gravel pits, ash disposal areas of power plants, reservoir shorelines, and other man-made sites (Texas Parks and Wildlife 2009).

4.3.8 Management and Protection

In 1990, the USFWS published a recovery plan for the interior population of least tern (USFWS 1990b). That plan includes recovery goals for the least tern along major river systems throughout the species' range. Major recovery steps outlined in the plan include: (1) determine population trend and habitat requirements; (2) protect, enhance, and increase populations during breeding; (3) manage reservoir and river water levels to the benefit of the species; (4) develop public awareness and implement educational programs about the least tern; and (5) implement law enforcement actions at nesting areas where there are conflicts with high public use.

Protection of interior populations of least terns requires rivers to be maintained at levels that avoid flooding natural nesting areas wherever possible. Currently, the USACE manages both flood control and least tern habitat on the Missouri River system, meaning that least tern habitat is frequently flooded during the nesting season to provide for other authorized system purposes (e.g., navigation and flood control). The USACE must often choose between inundating shoreline nests in a rising reservoir or releasing water from the dam and inundating habitat downstream (USACE 2009a). Whenever possible, the USACE regulates the system to reduce potential flooding of tern and plover nests on the Missouri River. River stages downstream of four of the mainstem dams are closely monitored, and releases are adjusted during the nesting season to prevent nest inundation when possible (USFWS 2000). Releases from Gavins Point Dam may be increased in early May, in time for the arrival of nesting terns, to force the birds to nest on higher sandbars so that navigation target flows can be met later in the nesting season when downstream tributary flows begin their normal decline in July and August (USFWS 2000). However, even with some system modifications, competing multipurpose demands (e.g., navigation and flood control) may conflict with uniform or constrained peaking summer releases for terns in downstream areas; and habitat along the Missouri River is often flooded during the breeding season (USACE 2009a).

State, federal, and private organizations throughout the United States are collaborating to provide protection to the interior least tern though bird census, research, curtailment of human disturbance, and provision suitable habitat. Continued monitoring of confirmed and potential colony sites is underway to assess population status and reproductive success. Protective measures such as signs and fences are being implemented to restrict access to sites most threatened by human disturbance. Other management strategies include vegetation control at occupied sites, chick shelter enhancement, predator control, pollution abatement, and habitat creation/restoration at unoccupied sites.

4.4 NORTHERN LONG-EARED BAT

4.4.1 Description

The northern long-eared bat (*Myotis septentrionalis*) *is* a medium-sized bat with a body length of 3 to 3.7 inches but a wingspan of 9 to 10 inches. Their fur color can be medium to dark brown on the back and tawny to pale-brown on the underside (USFWS 2015). As its name suggests, this bat is distinguished by its long ears, particularly as compared to other bats in its genus, *Myotis*. Like most bats, northern long-eared bats emerge at dusk to feed. They primarily fly through the understory of forested areas feeding on moths, flies, leafhoppers, caddisflies, and beetles, which they catch while in flight using echolocation or by gleaning motionless insects from vegetation.

4.4.2 Status

The northern long-eared bat is listed as a threatened species under the federal Endangered Species Act. No critical habitat rules have been published for the Northern long-eared Bat (USFWS 2015).

4.4.3 Threats

No other threat is as severe and immediate to the Northern long-eared bat as the disease, white-nose syndrome. If this disease had not emerged, it is unlikely the northern long-eared bat would be experiencing such a dramatic population decline. Since symptoms were first observed in New York in 2006, white-nose syndrome has spread rapidly from the Northeast to the Midwest and Southeast; an area that includes the core of the northern long-eared bat's range where it was most common before this disease. Numbers of northern long-eared bats (from hibernacula counts) have declined by up to 99 percent in the Northeast. Although there is uncertainty about the rate that white-nose syndrome will spread throughout the species' range, it is expected to spread throughout the United States in the foreseeable future (USFWS 2015).

Gates or other structures intended to exclude people from caves and mines not only restrict bat flight and movement, but also change airflow and internal cave and mine microclimates. A change of even a few degrees can make a cave unsuitable for hibernating bats. Also, cave-dwelling bats are vulnerable to human disturbance while hibernating. Arousal during hibernation causes bats to use up their already reduced energy stores, which may lead to individuals not surviving the winter.

Highway construction, commercial development, surface mining, and wind facility construction permanently remove habitat and are activities prevalent in many areas of this bat's range. Forest management benefits northern long-eared bats by keeping areas forested rather than converted to other uses. But, depending on type and timing, forest management activities can cause mortality and temporarily remove or degrade roosting and foraging habitat.

4.4.4 Reproduction and Development

Breeding for the Northern long-eared bat begins in late summer or early fall when males begin swarming near hibernacula. After copulation, females store sperm during hibernation until spring, when they emerge from their hibernacula, ovulate, and the stored sperm fertilizes an egg. This strategy is called delayed fertilization. After fertilization, pregnant females migrate to summer areas where they roost in small colonies and give birth to a single pup. Maternity colonies, with young, generally have 30 to 60 bats, although larger maternity colonies have been observed. Most females within a maternity colony give birth around the same time, which may occur from late May or early June to late July, depending where the colony is located within the species' range. Young bats start flying by 18 to 21 days after birth. Adult northern long-eared bats can live up to 19 years.

4.4.5 Range

The northern long-eared bat is found across much of the eastern and north central United States and all Canadian provinces from the Atlantic coast west to the southern Northwest Territories and eastern British Columbia. The species' range includes 37 states: Alabama, Arkansas, Delaware, District of Columbia, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, New Jersey, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, South Carolina, South Dakota, Tennessee, Virginia, West Virginia, and Wisconsin.

4.4.6 Population Level

To date there are no publications readily available that offer the overall population status of the northern long-eared bat. Although they are typically found in low numbers in inconspicuous roosts, most records ofNLEBs are from winter hibernacula surveys (USFWS 2015). More than 780 hibernacula have been identified throughout the species' range in the United States, althoughmany hibernacula contain only a few (1 to 3) individuals (Whitaker and Hamilton 1998). Known hibernacula (sites with one or more winter records of NLEB) include: Alabama (2), Arkansas (41), Connecticut (8), Delaware (2), Georgia (7), Illinois (21), Indiana (25), Kentucky (119), Maine (3), Maryland (8), Massachusetts (7), Michigan (103), Minnesota (11), Missouri (more than 269), Nebraska (2), New Hampshire (11), New Jersey (7), New York (90), North Carolina (22), Oklahoma (9), Ohio (7), Pennsylvania (112), South Carolina, (2), South Dakota (21), Tennessee (58), Vermont (16), Virginia (8), West Virginia (104), and Wisconsin (67). NLEB have been documented in hibernacula in 29 of the 37 States in the species' range. Other States within the species' range have no known hibernacula (due to no suitable hibernacula present, lack of survey effort, or existence of unknown retreats).

4.4.7 Habitat

During summer, northern long-eared bats roost singly or in colonies underneath bark, in cavities, or in crevices of both live and dead trees. Males and non-reproductive females may also roost in cooler places, like caves and mines. This bat seems opportunistic in selecting roosts, using tree species based on suitability to retain bark or provide cavities or crevices. It has also been found, rarely, roosting in structures like barns and sheds. Northern long-eared bats spend winter hibernating in caves and mines, called hibernacula. They typically use large caves or mines with large passages and entrances; constant temperatures; and high humidity with no air currents. Specific areas where they hibernate have very high humidity, so much so that droplets of water are often seen on their fur. Within hibernacula, surveyors find them in small crevices or cracks, often with only the nose and ears visible.

4.4.8 Management and Protection

Management of this species is in its infancy since only being listed as threatened as of May 4, 2015. The USFWS issued a 4(d) rule allowing for flexibility in the ESA's implementation and to tailor prohibitions to those that make the most sense for protecting and managing at-risk species. This rule, which may be applied only to species listed as threatened, directs the Service to issue regulations deemed "necessary and advisable to provide for the conservation of threatened species." The 4(d) rule ensures private landowners and citizens are not unduly burdened by regulations that do not further the conservation of the species and are exempted from "take" prohibitions (defined in the ESA as to harass, harm, pursue, hunt, shoot, wound, kill, etc.), when conducting certain activities. The rule is often used to clarify or simplify what forms of take of a threatened species are and are not prohibited. Without a 4(d) rule, threatened wildlife species automatically get the same protections as endangered species under section 9 of the ESA and FWS regulations.

The USFWS implemented a 4(d) because the primary threat to the northern long-eared bat is white-nose syndrome. This disease, first discovered in the winter of 2006-2007, has decimated many cave-hibernating bat populations in the Northeast. Since that time the disease or the fungus that causes it has spread to 28 of the 37 states (plus the District of Columbia) within the range of the northern long-eared bat. Now that the northern long-eared bat is listed under the ESA, incidental take of a bat while conducting any of these otherwise lawful activities would be prohibited without a permit or authorization. However, a 4(d) rule allows the Service to avoid regulating activities that may benefit the species or cause only limited amounts of take. This would then allow the Service and our partners to focus on actions that are most important to conserving northern long-eared bats.

4.5 INDIANA BAT

4.5.1 Description

The Indiana bat (*Myotis sodalis*) weighs a quarter of an ounce and has a wingspan from 9 to 11 inches (USFWS 2006b). The fur is dark-brown to black and is similar in appearance to many other related species. The Indiana bat is a very social species, and large numbers of individuals cluster together during hibernation (USFWS 2006b). Common prey includes a variety of flying insects found along rivers or lakes and in uplands.

4.5.2 Status

The Indiana bat was listed as endangered on March 11, 1967 (USFWS 2006b). Critical habitat for the species was designated on September 24, 1976 (41 FR 41914) but does not include any caves within the Action Area.

4.5.3 Threats

No other threat is as severe and immediate to the Northern long-eared bat as the disease, white-nose syndrome. If this disease had not emerged, it is unlikely the northern long-eared bat would be experiencing such a dramatic population decline. Since symptoms were first observed in New York in 2006, white-nose syndrome has spread rapidly from the Northeast to the Midwest and Southeast; an area that includes the core of the northern long-eared bat's range where it was most common before this disease. Numbers of Indiana ats (from hibernacula counts) have declined precipitously across its range. Although there is uncertainty about the rate that white-nose syndrome will spread throughout the species' range, it is expected to spread throughout the United States in the foreseeable future (USFWS 2015).The Indiana bat is extremely vulnerable to disturbance because it hibernates in large numbers in only a few caves (USFWS 2006b). During hibernation, the bats cluster in groups of up to 500 individuals per square foot, and the largest hibernation caves can support from 20,000 to 50,000 bats. Large numbers of Indiana bat deaths have occurred due to human disturbance, such as cave exploration during hibernation. Between early spring and autumn, Indiana bats migrate to and use summer roosting and foraging areas located in riparian, floodplain, and upland forests (MDC 2010b, USFWS 2007). Between 2007 and 2009, the Missouri population of Indiana bat declined by 14 percent (USFWS 2011c). Current threats to the species include changes in summer habitats from alterations to land cover, the reduction in roosting and foraging forested habitat, and white-nose syndrome (MDC 2010b, USFWS 2010b). Population declines may also be attributed, in part, to the use of pesticides and other environmental contaminants. Bats may be affected by eating contaminated insects, drinking contaminated water, or absorbing the chemicals while feeding in areas that have been recently treated (USFWS 2006b).

4.5.4 Reproduction and Development

The Indiana bat mates during fall before they enter caves to hibernate. Females store the sperm through winter and become pregnant in spring soon after emerging from the caves (USFWS 2006b).

After migrating to summer areas, females roost under the peeling bark of dead and dying trees in maternity colonies of 100 or more bats. Each female in the colony gives birth to only one pup per year. Young bats are nursed by the mother, who leaves the roost tree only to forage for food. The young stay with the maternity colony throughout their first summer (USFWS 2006b).

4.5.5 Range

The Indiana bat is found over most of the eastern half of the United States. Almost half of all Indiana bats hibernate in caves in southern Indiana, and states with bat populations over 40,000 (in 2005) included Missouri, Kentucky, Illinois, and New York. Other states within the current range of the Indiana bat include Alabama, Arkansas, Connecticut, Iowa, Maryland, Michigan, New Jersey, North Carolina, Ohio, Oklahoma, Pennsylvania, Tennessee, Vermont, Virginia, and West Virginia (USFWS 2006b).

The Indiana bat occurs seasonally during summer along streams and rivers in northern Missouri. The species hibernate through winter in caves and abandoned mines in the Ozarks.

4.5.6 Population Level

The USFWS 2005 population estimate is about 457,000 Indiana bats, half as many as when the species was listed as endangered in 1967 (USFWS 2006b). In 2005, almost half of all Indiana bats (207,000) hibernated in caves in southern Indiana, followed by populations amounting to 65,000 in Missouri, 62,000 in Kentucky, 43,000 in Illinois, and 42,000 in New York (USFWS 2006b).

As of October 2006, the USFWS had records of extant winter populations at approximately 281 hibernacula in 19 states and 269 maternity colonies in 16 states (USFWS 2007b). Within Missouri, populations of Indiana bats are found in St. Louis County (winter population), Charlton County (summer populations), and Franklin and Boone Counties (summer and winter populations).

4.5.7 Habitat

The Indiana bat hibernates during winter in caves or abandoned mines. For hibernation, they require cool, humid caves with stable temperatures between 32° and 50° Fahrenheit (F). Very few caves within the bat's range have these conditions (USFWS 2006b).

After hibernation, the Indiana bat migrates to its summer habitat in wooded areas, where it usually roosts under loose tree bark on dead or dying trees. During summer, males roost alone or in small groups while females roost in larger groups of up to 100 bats (USFWS 2006b). Maternal colonies may occur in riparian or upland trees on river banks. Indiana bats also forage in or along the edges of forested areas.

4.5.8 Management and Protection

The USFWS developed a recovery plan in 1976, followed by a revision in 1983 (USFWS 2006b). A newly revised recovery plan for the Indiana bat was completed in 2007 (USFWS 2007b).

Some public lands like national wildlife refuges, military areas, and U.S. Forest Service lands are managed for Indiana bats by protecting forests. Management actions include ensuring that there are adequate species and sizes of trees needed by Indiana bats for roosting, and providing a supply of dead and dying trees that can be used as roost sites. In addition, caves used for hibernation are managed to maintain suitable conditions for hibernation and eliminate disturbance (USFWS 2006b). Collaboration continues with federal, state, and private organizations to improve bat habitat throughout their range.

4.6 DECURRENT FALSE ASTER

4.6.1 Description

The decurrent false aster (*Boltonia decurrens)* is a perennial plant that grows from 1 to 5 feet tall and occasionally reaches heights of over 6 feet. This plant is called "decurrent" because the leaf tissue extends down the stem from the point of leaf attachment (MDC 2011c). It is endemic to Illinois and central eastern Missouri, and is one of the rarest native species in this region (Center for Plant Conservation 2010).

Decurrent false aster is closely related to *Boltonia asteroides* var. *recognita*, a common weedy species of false aster that is sometimes found in the same habitat (MDC 2011c).

4.6.2 Status

The decurrent false aster was federally listed as threatened on November 14, 1988 (53 FR 45858). No critical habitat rules have been published for the decurrent false aster.

4.6.3 Threats

A major cause of the decurrent false aster's decline is intensive agricultural practices that increase topsoil runoff, smothering seeds and seedlings (USFWS 2009a). Further, agriculture has eliminated wet prairies and marshes within the species' range, and natural lakes have been drained and converted to croplands. Building levees along rivers and draining wetlands for cultivation has changed patterns of flooding and eliminated habitat, resulting in degradation of the species. Other current threats to the species include the use of herbicides (USFWS 2009a).

4.6.4 Reproduction and Development

Decurrent false aster blooms from July to October and bears seeds from August to October. They occur in branched groups of composite heads with yellow disk flowers and white to purplish ray flowers.

4.6.5 Range

Historically, this species was found on the shores of lakes and the banks of streams; today, it is most common in disturbed lowland areas (USFWS 1988b). The range of decurrent false aster is along the Illinois River in west central Illinois and along the Mississippi River near St. Louis, primarily within Illinois (Center for Plant Conservation 2010).

In Missouri, the distribution of decurrent false aster is restricted to the Mississippi River floodplain from the Illinois River southward. Current populations are more isolated than their former distribution and the plant is presently known to occur only in St. Charles County, Missouri.

The species is known to occur in the Big Muddy National Wildlife Refuge (USFWS 2011c). A few populations occur on private land, often in association with agricultural crop production. Levees and roadsides may support small populations. It seems likely that additional populations occur on private land that are yet to be recorded (MDC 2011c).

4.6.6 Population Level

The number of identified sites with above-ground plants varies from year to year. The majority of sites are in Illinois, with only one or two extant populations in Missouri (USFWS 1990a). In some years, some sites have been reported to have hundreds of thousands of individuals (USFWS 1990a).

4.6.7 Habitat

Habitat for this species is moist, sandy soil. It grows in wetlands, on the borders of marshes and lakes, and on the margins of bottomland oxbows and sloughs (MDC 2011c). Decurrent false aster favors recently disturbed areas, and it relies on periodic flooding to scour away other plants that compete for the same habitat (USFWS 2009a).

4.6.8 Management and Protection

A recovery plan was established for decurrent false aster on September 28, 1990 (USFWS 1990a). Many populations of the decurrent false aster are on public land, particularly on wetlands managed by the USACE. These populations are being managed by participating state and federal agencies through periodic flooding and mowing (MDC 2011c).

SECTION 5

Environmental Baseline and Cumulative Effects

This section identifies and describes past and ongoing human and natural factors leading to the current status of the species, its habitat, and ecosystem within the Action Area, except those caused by the action. This information is used, along with information describing the status of the species and critical habitat within the Action Area, to describe the expected condition of the species and their habitat without exposure to the proposed federal action. .

5.1 DESCRIPTION OF ENVIRONMENTAL BASELINE

The environmental baseline is defined as the effects of past and ongoing human induced and natural factors leading to the status of the species, its habitat, and ecosystem, within the Action Area. The environmental baseline is a snapshot of the pallid sturgeon's status at this time, and provides the context for the analysis of effects of the proposed federal action on listed species. In this biological assessment, the environmental baseline is described in Sections 4 and 6, as well as by information provided in this section. Details of the pallid sturgeon's habitat description, life history, population status, and known locations are included in Section 4. Given the large amount of information, extent of the Action Area, and complexities of the LOMR, discussion of environmental baseline is also provided in the context of the effects analysis in Section 6.

The Missouri River has been heavily modified from pre-settlement conditions. Since the 1930s, two major man-made modifications to the Missouri River have been constructed, resulting in dramatic long-term changes to the character of the LOMR. A series of dams and reservoirs at the upper end of the river (known as the Missouri River Mainstem Reservoir System) were built between 1936 and 1963, and substantially altered the character of flows and sediment supply in the LOMR. In addition to reservoirs, the Missouri River navigation channel is maintained by a complex series of dikes and revetments constructed by the Missouri River Bank Stabilization and Navigation Project (BSNP). These structures concentrate the flow of the river to maintain a channel depth sufficient for commercial barge traffic. Refer to Section 3 in the FEIS (USACE 2011) for detailed information on the LOMR basin's geographic water resources, aquatic ecology, wetlands, and terrestrial resources.

5.1.1 River Hydrology

Flows in the LOMR, or the hydrology, drive the geomorphic processes that shape the river. The amount and velocity of water flowing are the main factors in determining how much sediment is moving through the system. Dams built over 50 years ago upriver from the Action Area have affected the magnitude and timing of flows, and levees and dikes have constrained flows and altered flood peaks. For further discussions on geology and geomorphology, including existing bed degradation due to past human modification, see Sections 2.4 and 3.4 in the FEIS (USACE 2011).

5.1.2 Current Practices

This section summarizes the existing regional and unrelated federal actions within the Action Area that may affect listed species and their habitat. Major uses of the LOMR include current navigation, water operations and management, recreational uses, and commercial sand and gravel production. Sand and gravel have been dredged or excavated from the river since the 1930s. The USACE recently completed a description of river and land use management and a history of the river management era for the LOMR in association with its proposal to permit commercial sand and gravel dredging (USACE 2011). Dredging has been identified as one of main causes of stream bed degradation; however, the effects of commercial dredging have not been monitored extensively.

The USACE has implemented numerous projects along the Missouri River in response to the BiOp by the USFWS (USFWS 2000, 2003). These projects are basically designed to improve habitat for endangered native bird and fish species that occur along the LOMR; they can be grouped into emergent sandbar habitat (ESH) projects designed to benefit bird species and SWH projects mainly for the benefit of pallid sturgeon (NAS 2010). Current activities that influence the geomorphic character of the river include:

- Ongoing maintenance of BSNP structures, including changing dike heights and lengths;
- Activities to change the channel configuration or sediment loads such as dike notching;
- Activities associated with the Missouri River Recovery Program (creation of SWH such as side channels and chutes); and
- Dredging for levee construction and channel maintenance dredging.

The Missouri River Recovery Program Project is the only activity with a likelihood of changing the channel configuration or sediment loads of the river. Ongoing studies that are gaining knowledge about where there are deficits and surpluses of sediments could be factored into the placement of SWH projects that will likely reintroduce sediment. The ongoing degradation studies may inform river management about where other actions may occur during the permit period. The most likely reach where changes could occur in management action is the Kansas City reach. The actions likely would focus on widening of the river in this reach to reduce flood heights and scour. Likely strategies would include excavation of side channel chutes or backwaters and dike and revetment notching that would release large quantities of stored sediment from overbank areas (those areas of the floodplain between the river bank and levees where floodwaters have deposited fine-grained sediment from suspension). After initial effects of sediment pulses, such as higher turbidity and bed load movement, positive habitat benefits could be habitat diversification, areas of lower flow for refuge, and aggradation of habitat patches to help stabilize some areas of the benthic environment. These areas are most likely to occur on the channel margins because the navigation channel would be maintained by the controlled erosion dike-directed flows.

Maintenance dredging typically results in no net gain or loss of sediments because most of the material is moved to within the high banks of the river and eventually rerouted within the channel. Displacement of the material may alter patches of shoreline area vegetation if placed above the ordinary high water mark. Vegetation will recover, and placement of the dredged material simulates a sediment deposition event that would have occurred more frequently from overbank flows prior to river management.

The USACE receives miscellaneous requests for authorization of dredge fill material removal. The USACE typically requires extensive sediment studies for such requests, and a demonstration of surplus sediment would be required for the USACE to allocate removal beyond current authorizations.

5.2 CUMULATIVE EFFECTS

Cumulative effects include the effects of future state, tribal, local or private actions that are reasonably certain to occur in the Action Area, and are considered in the biological assessment. Future federal actions that are unrelated to the LEDPA are not considered in this section because they are subject to separate consultation(s) under Section 7 of the Act. The USACE is unaware of any additional significant state, tribal, local or private actions that are reasonably certain to occur in the action area producing cumulative effects beyond those ongoing effects already considered in the herein.

5.2.1 Past Actions

The Missouri River ecosystem was historically a highly dynamic, highly variable river system; but it experienced a marked ecological transformation during the 20th century. At the beginning of the century, the Missouri River was notorious for large floods, for a sinuous and meandering river channel that moved freely across its floodplain, and for massive sediment transport. Prior to channelization and flow regulation, the LOMR was braided to highly sinuous, a form naturally found in rivers with broad floodplains and heavy sediment loads. The river was characterized by log jams, snags, whirlpools, chutes, bars, cut-off channels, and secondary channels around bars. The main channel typically had a deep thalweg (the deepest part of the river) that contained the faster-moving flow and a shallower section(s) on one or both sides of the channel.

By the end of the 20th century, the Missouri River was channelized, with its flow highly regulated; it bore little resemblance to the previously wild, free-flowing river (NRC 2002). Unlike the historical river system, the current system is highly altered—both hydrologically and physically. With construction of the BSNP, the river bank top width has been reduced; side channels, islands, and ephemeral sand bars have been lost; and the physical process of channel meandering has been arrested. Sediment transport and availability for habitat development have been significantly impaired. The dams and BSNP structures have reduced the sediment availability to the lower river by almost six-fold (from 229 million metric tons to 40 million metric tons [NRC 2002]). These changes have resulted in significant cascading ecological effects on the health of the river and its biota.

The development of dams, water diversion structures, and structures to provide for flood control and navigation has substantially altered the natural processes that influenced the evolution of species in the Missouri River. Dam operations have considerably altered the timing and magnitude of river flows; and the low flows that ordinarily occurred throughout summer, fall, and winter are largely nonexistent under many water-year types.

Today, the Missouri River is one of the most highly modified and managed rivers in the world. The history of the development of the Missouri River, the reservoir systems, and the BSNP—and the associated impacts on the Missouri River ecosystem—are described in the FEIS (USACE 2011) and in many other accounts (NRC 2002, Galat et al. 2004; USACE 2009a, USFWS 2003). Therefore, they are not discussed further here.

From 1984 to 2006, more than $133 million was expended on habitat restoration activities on the LOMR (Jacobson, Blevins, and Bitner 2009). Initially, efforts focused on mitigating effects of the BSNP by restoring a variety of aquatic and terrestrial habitats. To comply with findings in the 2003 BiOp that USACE management of the Missouri River put the survival of the pallid sturgeon in jeopardy (USFWS 2003), restoration activities began in 2004 to emphasize creation of shallow water aquatic habitat. SWH is thought to be important for rearing of larval and juvenile pallid sturgeon, as well as essential habitat to support native aquatic species and biodiversity (USFWS 2003).

5.2.2 Present and Future Non-Federal Actions

Potential non-federal projects that could cumulatively affect listed species in the LOMR include future transportation improvements and energy development projects associated with nuclear power plants or placement of hydrokinetic turbines in the river channel.

5.2.2.1 Transportation Improvement Projects

Transportation improvement can significantly influence demand for gravel and sand from the LOMR. The significant decrease in highway and bridge construction in the 2010–2014 Missouri Statewide Transportation Improvement Program (STIP) reflects lower state revenues, uncertain federal funding, and limited proceeds from existing bond programs. Many of the larger-scale projects included in the previous year's STIP, such as the Mississippi River Bridge project in St. Louis, many of the Safe and Sound Bridge Improvement projects, and the federal American Recovery and Reinvestment Act of 2009 projects, are under construction. Although the 2010–2014 STIP contains many remaining bonded projects and the remaining Safe and Sound Bridge Improvement projects, the 5-year construction program is less than one-half the size of the previous 5 years. By 2011, transportation funding will drop by more than one-half and will continue falling to only one-third of the 2010 amount in subsequent years (MoDOT 2010).

5.2.2.2 Energy Development Projects

In July 2008, AmerenUE submitted an application to the U.S. Nuclear Regulatory Commission for a combined construction and operating license for a new nuclear power plant alongside its existing single unit at Callaway, Missouri. In April 2009, AmerenUE suspended efforts saying that state policies were making it too difficult to finance the project (World Nuclear News 2009). Although the project has not been cancelled, it is not considered a reasonably foreseeable action and therefore is not included in the cumulative effects analysis.

In April 2008, Free Flow Power Company submitted preliminary permit applications to the Federal Energy Regulatory Commission (FERC) to study 25 regions of the mainstem of the Missouri River for the feasibility of placing hydrokinetic turbines to produce electricity. FERC granted the permits in October 2008 and February 2009. In September 2009, Free Flow Power withdrew the preliminary permit applications, stating that—based on consultation and analysis of bathymetry and velocity—depth, river bed degradation, and the uncertainty surrounding the renewal of dredging permits were significant obstacles to hydrokinetic development at that time (Free Flow Power Company 2009). Consequently, the proposed placement of hydrokinetic turbines within the mainstem of the Missouri River is not considered a reasonably foreseeable action and is not included in the cumulative effects analysis.

SECTION 6

Effects of the Action

This section includes an analysis of the direct and indirect effects on listed species and their critical habitat that are associated with the proposed action and its interrelated and interdependent actions. Potential direct effects on listed species would include entrainment into the dredges, direct physical disturbance of the river bottom and associated changes in substrate composition, changes in water quality, noise and physical disturbance-induced changes in behavior, and loss of some terrestrial habitat. These potential direct impacts would occur in the vicinity of dredge barges, towboats, and land-based sand plants. The impacts would be limited to the period during or shortly after dredging and towboat operation, sorting and loading at plant locations, and new sand plant construction. Individual organisms could be affected through injury, mortality, or behavioral modifications arising mostly from direct disturbance or habitat modification.

Potential indirect effects may result from changes in channel morphology and related effects on instream and floodplain habitats used by pallid sturgeon. These may occur due to changes in river sediment regime changes and associated changes in geomorphic processes as a result of sand and gravel removal. Indirect effects could occur in the short term or in the long term.

Below is a discussion of potential impacts to each of the listed species identified by the USFWS as potentially occurring in the Action Area. The documented occurrence and geographic distribution of listed species in the Action Area; their life history, movements, and migrations; and their habitat needs are considered in this assessment, in relation to the amounts and locations of commercial sand and gravel dredging that would occur under the LEDPA. The potential direct and indirect effects of dredging and related activities on the reproduction, growth, maturation, movements, and migrations of each species are considered in this section and are integrated with the most up-to-date literature, research results, and data available.

6.1 PALLID STURGEON

This section includes an analysis of the direct and indirect effects to the pallid sturgeon and its habitat that is associated with the proposed action and its interrelated and interdependent actions.

Special conditions and dredging exclusion zones, such as excluding dredging in potential sturgeon spawning areas, some tributaries, river chutes, side channels, areas adjacent to conservation lands and in areas adjacent to certain infrastructure facilities, have been in effect under the 2011 ROD and will continue (see Section 3.5). In addition, limits on dredging intensity are implemented at the reach scale to reduce the effects of locally intense dredging. Finally, monitoring of channel bottom elevations as a measure of bed degradation has been implemented under the 2011 ROD, allowing actual levels of bed change to be measured and addressed.

Potential direct and indirect effects on pallid sturgeon include impacts on individuals in the LOMR and impacts on potential pallid sturgeon habitat. Individual effects may include mortality or harm due to propeller damage by dredge barges and towboats or entrainment into the dredge; physical alteration of important habitat features within dredging areas and the associated forage base; behavioral changes, changes due to increased noise around the dredges or tugs or increased turbidity downstream of the dredges; and potential blockage of spawning migration corridors during dredging. These potential direct impacts could occur in the vicinity of dredge barges, towboats, and land-based sand plants. The impacts would be limited to the periods during or shortly after dredging and towboat operation, sorting and loading at plant locations, and new sand plant construction. Individual organisms could be affected through injury, mortality, or behavioral modifications arising mostly from direct disturbance or habitat modification.

Potential indirect effects may result from changes in channel morphology and related effects on instream and floodplain habitats used by pallid sturgeon. These may occur due to changes in river sediment regime and associated changes in geomorphic processes as a result of sand and gravel removal. Indirect effects could occur in the short term or in the long term.

Potential direct and indirect effects on pallid sturgeon include impacts to individuals that may or may not affect the population level in the LOMR and impacts to habitat important to pallid sturgeon. This section is divided into two subsections: potential effects on pallid sturgeon and potential effects on pallid sturgeon habitat.

6.1.1 Potential Effects on Pallid Sturgeon

Individual and population-level impacts may include mortality or harm due to propeller damage by dredge barges and towboats or entrainment into the dredge, physical alteration of important habitat features within the dredging areas and the associated forage base, behavioral changes due to increased noise around the dredges or tugs or increased turbidity downstream of the dredges, and potential blockage of spawning migration corridors during dredging.

6.1.1.1 Navigation Propeller Entrainment

The effect of tugboat propellers on fish populations is a concern associated with potential increases in commercial navigation traffic (Killgore et al. 2001; Killgore et al. 2005). Towboats are used to move and position barges on the LOMR, resulting in the potential for injury or mortality to pallid sturgeon eggs, larvae, or juveniles that pass through the propeller field. The USFWS (2004) concluded that entrainment due to dredging operations and commercial navigation traffic represents an unknown, but perhaps significant, threat to the species through direct mortality.

To date, the baseline effects of navigation traffic related to propeller entrainment and mortality rates have not been evaluated in the LOMR, or more specifically, for pallid sturgeon, and only limited field assessments have been completed elsewhere. Rates of entrainment of pallid sturgeon on the LOMR are unknown and are expected to vary based on site-specific and species-specific conditions, including river hydrology, seasonal distribution of pallid sturgeon, the density of pallid sturgeon within a river segment during dredging operations, and the life history stage encountered during the period of barge or towboat traffic. Because useful propeller entrainment evaluations have been conducted on the Mississippi and other large rivers, this information is used as the best available. However, on the LOMR, barge sizes, load configuration, towboat and propeller size, as well as populations densities of sturgeon, are considerably smaller than many of the studies cited below, and so care must be used when considering this information.

Studies on the Upper Mississippi River and Illinois River (found that towboats entrain large volumes of water through their propellers (Gutreuter et al. 2003; Killgore et al. 2005). Towboat propellers often exceed 8 feet (approximately 2.5 m) in diameter and span between 20 and 100 percent of the depth of a confined navigation channel in the Upper Mississippi River (Gutreuter et al. 2003). Dettmers (pers. comm.) confirmed that the majority of the towboats evaluated in Gutreuter et al. (2003) were 9-foot propellers. The areas within which water is disturbed by propellers (referred to as the “inflow zone”) for towboats on the Mississippi River were found to extend approximately 20 percent wider than the beam of the tugboat from centerline (Maynord 2000).

Ship propellers cause abrupt changes in hydraulic patterns due to increased turbulence and water velocities, pressure changes, and shear forces (Maynord 1990, Hyun and Patel 1991). Ship propellers also can injure or kill fish if the fish come in contact with the blades (Gutreuter 2003). Cada (1990) reported that fish eggs and larvae that pass through water currents induced by a propeller may come in contact with the blade and can experience stresses from pressure changes and shear forces as a result of abrupt changes in hydraulic patterns caused by the propellers. Killgore et al. (2001) evaluated mortality of icthyoplankton entrained through a scale model of a tugboat propeller. They found mortality to be a linear function of shear stress for all species and life stages. Larger larvae (e.g., shovelnose sturgeon) experienced lower mortality, while smaller larvae (e.g., lake sturgeon and blue suckers) experienced higher mortality. All larval species experienced delayed mortality, particularly at higher stress levels. Killgore et al. (2001) concluded that shear stress caused by tugboat traffic is probably a primary force contributing to the mortality of icthyoplankton entrained during vessel passage, but the magnitude of mortality is dependent on the individual size of icthyoplankton.

Gutreuter et al. (2003) developed a method to estimate mortality rates of adult fish caused by entrainment through the propellers of commercial towboats operating in river channels. They estimated entrainment mortality rates of adult fishes in Pool 26 of the Upper Mississippi River and Alton Pool of the Illinois River, where fish kills attributed to entrainment were observed. Their estimates of entrainment mortality rates were 0.53 fish/kilometer (km) of tugboat travel for shovelnose sturgeon (80 percent confidence interval, 0.00 – 1.33 fish/km). They concluded that their approach applies more broadly to commercial vessels operating in confined channels, including other large rivers and intra-coastal waterways. In its consideration of this information, it was the EPA's opinion that it is likely that tugboat traffic is a source of incidental mortality to adult pallid sturgeon (USEPA 2007). But in a report not cited by the USEPA (2007), Kilgore et al. (2005) reported on the results of an evaluation of towboat propeller-induced mortality of juvenile and adult fish in the same study area – Pool 26 of the Upper Mississippi River and Illinois River. The study used a specifically-designed net deployed from a twin-screw towboat to filter the propeller wash of towboats. Kilgore et al. (2005) reported that in a total of 139 10-minute trawls over a two-year period, benthic species were rarely collected, and only one sturgeon was collected with no evidence of propeller-type injuries. The disparity in the numbers of shovelnose sturgeon collected in the two studies discussed above adds uncertainty to calculating sturgeon entrainment due to towboats.

Firm conclusions cannot be made about the rate or significance of propeller entrainment and mortality in the LOMR. For larval and young juvenile, based on the literature findings, the extent of mortality would likely be a function of the amount of towboat traffic in a given river segment, towboat speed, and traffic volumes during the period when pallid sturgeon are most susceptible to shear stress (i.e., the larval or early juvenile life stages). The amount of vessel traffic, with the associated risk of injuring or killing fish, therefore is an important consideration. We used the findings of existing studies as the best available information to address this issue.

As part of the Restructured Mississippi and Illinois River Navigation Feasibility Study, the USACE conducted several studies on the Middle Mississippi River (USACE 2004b) to determine the impacts of navigation traffic on fisheries resources. Entrainment of fish larvae had been of particular concern; however, the USACE also conducted studies to evaluate entrainment of juvenile and adult fish, including pallid sturgeon (USACE 2004b), Bartell and Nair 2003).

In order to estimate the impacts of commercial navigation traffic on fish populations due to larval fish entrainment, the USACE conducted complex modeling studies using a model called NavLEM (USACE 2004b), Bartell and Nair 2003). Much of the following discussion is summarized from the *Final Biological Opinion of the Upper Mississippi River – Illinois Waterway System Navigation Study* (USFWS 2004). The results indicated that approximately 4.8 million sturgeon larvae were estimated to be entrained and killed per year by baseline commercial navigation totaling approximately 2.0 million miles (Bartell and Nair 2003). These estimated numbers of entrained and killed larvae are difficult to evaluate directly given that natural rates of larval fish mortality are high (Bartell and Nair 2003) and fish typically produce large numbers of eggs and larvae (USACE 2004b). To put this in perspective, the 4.8 million sturgeon larvae were estimated to represent approximately 0.81 percent of the sturgeon larvae produced in the open river during the year 2000 spawning season (Bartell and Nair 2003).

The model was then used to translate the estimates of baseline larval entrainment into equivalent adult fish lost due to commercial navigation traffic (USACE 2004b, Bartell and Nair 2003). Using this information and the ratio of pallid sturgeon to shovelnose sturgeon of 1:84, this equated to approximately 35 pallid sturgeon being lost in the Middle Mississippi River in the baseline condition. Further, the model estimated that 59 sturgeon recruits were lost due to commercial navigation in the Middle Mississippi River (Bartell and Nair 2003). This equates to approximately two pallid sturgeon recruits being lost every 3 years.

The other method of estimating entrainment mortality for pallid sturgeon used by the USACE (2004a) and the USFWS (2004) was a combination of two sources of information: (1) mortality rates (fish/km) determined by Guetreter et al. (2003) and USFWS (2004) and adjusted to sturgeon; (2) the number of miles of commercial navigation/barge traffic; and (3) the ratio of pallid sturgeon to shovelnose sturgeon. The mortality rate estimate for shovelnose sturgeon was determined to be 0.000002 shovelnose sturgeon/km of towboat travel, and there was approximately one pallid sturgeon for every 84 shovelnose sturgeon (ratio 1:84). Overall, for 3.2 million km (approximately 2.0 million miles) of commercial navigation traffic per year, annual pallid sturgeon entrainment was estimated at one pallid sturgeon killed every 10 years.

It should be noted that a great deal of uncertainty is associated with modeling and estimating propeller-induced adult and larval fish mortality with these types of estimates, which are further explained in detail in USACE 2004a. The estimates describe above from the Upper Mississippi and Illinois Rivers cannot be applied directly to the LOMR, as many of the important contributing factors are very different. The actual numbers of pallid sturgeon lost in any given year would be a function of many factors, including overall sturgeon larvae abundance, distribution of larvae in the navigation channel (vertically and horizontally), navigation traffic levels during the larval drift period, and navigation channel depth.

In the LOMR the size of towboats, their propellers, and entrained volume of water are much smaller on the LOMR than on the Upper Mississippi and Illinois Rivers. Propeller sizes for the studies of Gutreuter et al. (2003) and Kilgore et al. (2005) were generally 2.5 m in diameter (9 feet); propeller sizes on the LOMR typically range from 0.8 m to 1.5 m (2.5 to 5 feet). As a result, the volumes of water that LOMR towboats entrain is considerably less in total volume and per mile of vessel movement that that for the Upper Mississippi and Illinois Rivers. Pallid sturgeon to shovelnose sturgeon ratios are much lower on the LOMR (roughly one pallid sturgeon for every 350 shovelnose sturgeon; Grady et al. 2001; Doyle and Starostka 2003) than on the Upper Mississippi (roughly one pallid sturgeon for every 84 shovelnose sturgeon). The level of towboat traffic on the LOMR is also less than that of the estimates of propeller mortality estimated for Pool 26 of the Mississippi River. The total commercial navigation miles traveled to deliver the dredged sand and gravel on the LOMR would be roughly 510,000 miles/year (a number based on the number of trips reported in the FEIS and an approximate average trip distance of 10 miles), as compared to a total of approximately 2.0 million miles/year for Pool 26. These factors would all lead to a lower probability of entrainment and lower estimates of entrainment mortality in the LOMR as compared to those reported above for the Mississippi and Illinois Rivers. The 2014 Recovery Plan concluded that although "...it is reasonable to conclude that towboat propellers can entrain and harm Pallid Sturgeon...," "comparable studies have not been conducted in waters commonly occupied by Pallid Sturgeon, thus, the magnitude of this threat is difficult to assess and additional research is needed" (USFWS 2014). Based on the entrainment mortality estimates described above as reported in USFWS (2004) and USFWS (2014), and on site-specific factors in the LOMR, the probability of propeller mortality on the LOMR would be extremely low and much less probable than that on the Mississippi River, and thus minor and discountable.

6.1.1.2 Dredging Entrainment

During dredging, the dredging head (with or without a cutter head) and a suction line are mounted on a boom (called a ladder) that is lowered to the river bed. The dredging head is plunged in into the sediment and covered almost entirely. Sediment is removed from the river bottom until the suction head comes into contact with hard materials (such as bedrock, large rock substrates, or consolidated sediment layers) or cannot be extended further—at which time the suction head does not advance further into the river bottom, and the amount of bottom sediments sucked into the suction head is greatly reduced. The dredge boom is then raised, the dredge is relocated, and excavation recommences.

Under the proposed action, the potential for injury and mortality to pallid sturgeon eggs, larvae, or juveniles exists for eggs or fish being drawn into the suction field of the dredge pump. Accurate information is lacking for the rate of pallid sturgeon entrainment into water intakes in the Action Area. Entrainment has been documented at power plant intakes (USFWS 2005) and in the irrigation canal supplied by Intake Dam on the Yellowstone River (Jaeger, Jordan, and Camp et al. 2004), but little data are available regarding the effects of dredge operations. The USACE St. Louis District and the DOER Program have completed work to assess dredge entrainment of fish species and the potential effects of these operations on larval and juvenile *Scaphirhynchus*. Reports include those of Reine and Clark (1998), Hoover et al. (2005), and USACE (2010c). The USACE conducted dredging entrainment susceptibility studies of sturgeon and paddlefish species (Hoover et al. 2005). Data for escape speed, station-holding ability, rheotaxis and response to noise, and dredge flow fields were used to develop a risk assessment model for entrainment of sturgeon by dredges. Intake water velocity and susceptibility to entrainment in the intake water flow were found to be the primary determinants for entrainment of individual organisms, presumably including pallid sturgeon. However, other secondary variables affecting swimming behavior and performance could also influence and determine entrainment rates (Boyson and Hoover 2009).

Susceptibility (risk of entrainment) depends on swimming behavior and performance (Boyson and Hoover 2009); some sturgeon life stages may also swim toward the dredge head for various reasons including visual, electro-receptive, or audible stimulation (Boyson and Hoover 2009). Researchers found that the rate of sturgeon entrainment at dredge heads would be determined, in part, by their location relative to the dredge, their swimming ability, and if they readily swim against the current (Hoover et al. 2005). While these factors are important in determining entrainment levels, other factors—such as the species' response to noise and turbidity, and its localized abundance and distribution—also would affect entrainment rates (Hoover et al. 2005).

Dredges create suction fields of various sizes, depending on their intake rate, head and pipeline diameter, and other factors. For example, a dredge can create an effect of approximately 1.6 feet per second (50 cm per second) up to a distance of 4.9 feet (1.5 m) from the dredge intake (Hoover et al. 2005). The entrainment studies conducted by Hoover et al. (2005) found that many pelagic, free-swimming fish with an escape speed equal to or greater than the intake velocity and those that are able to orient themselves with the flow would have a higher likelihood of escape, compared to slow-moving fish that cannot orient themselves toward the dredge flow field. A study that evaluated entrainment of white sturgeon found that similar variables dictated the rate of escape for different life history stages of that species (Boyson and Hoover 2009). Boyson and Hoover (2009) also found that smaller fish as a group, compared to larger juveniles and adults, had less endurance and slower swimming speeds, which increased their risk of entrainment.

Few answers and much uncertainty are present about the entrainment rate of pallid sturgeon (USFWS 2005) and the potential population-level effects of entrainment. In regard to the entrainment rate, most studies and the life history of pallid sturgeon suggest that larval and early juvenile would be the life stages most susceptible to entrainment (Peters and Parham 2008). This is because they have less swimming ability and swimming endurance, and because they drift somewhat passively over long distances as they develop and increase their swimming ability (Hoover et al. 2005). Once the eggs hatch, the larval pallid sturgeon drift downstream over long distances in the lower part of the water column, typically within 0.5 to 1 meter of the bottom. Larval drift is greatest adjacent to the bottom in the high-velocity thalweg (Braaten et al. 2010), where most dredging also occurs. In addition, some proportion of young larvae do not orient into the current, thus increasing the chance of coming into contact with a dredge intake field. As a combined result of all of these factors, larval pallid sturgeon in the LOMR may be susceptible to entrainment.

A recent report by the USACE (2010d) concluded that there is a slight possibility that some incidental take of pallid sturgeon could occur as a result of dredging during habitat creation projects. As reported in USACE (2010d), in April 2008, the USFWS initiated discussions with the USACE and other fishery experts regarding the impacts of ESH construction on pallid sturgeon and other fish, specifically with regard to the timing of dredging and construction activities. During those and subsequent discussions, experts from the USACE, USFWS, National Park Service, and South Dakota Game Fish and Parks concluded that no significant impact to pallid sturgeon was anticipated from these activities (USACE 2010d).

During 2008, a field study was conducted by the Engineer Research and Development Center (ERDC) and the Missouri Department of Conservation (MDC) to evaluate the presence or absence of the federally endangered pallid sturgeon in the discharge of operating sand dredges in the Mississippi River near St. Louis (RM 149.8). From September 30 to October 2, 2008, three methods were used to assess potential entrainment. Entrainment was directly assessed by sampling the dredged material and discharge materials with specially designed nets and seines. Discharge was filtered while the dredge was engaged in normal operations (dredge head mostly buried in the sand) and while the dredge head was positioned approximately 1–3 feet above the river bottom, to increase the probability of entrainment. Entrainment probability was assumed to be higher when the head was in the water column and not buried in the substrate. The ERDC and MDC study found no entrainment of fish as a result of the dredging operations performed (ERDC 2008).

In another study, for the entire period of 1990–2005, fewer than 25 cases of sturgeon entrainment by dredges operating in Gulf and Atlantic waters were confirmed (Hoover et. al. 2005). Finally, a study of entrainment of sturgeon by dredging operations was completed by the Hoover et al. (2008) near Duck Island, near the confluence of the Missouri and Mississippi Rivers. Over a 3-month dredging period, entrainment of four individual juvenile sturgeon was documented; all had incurred physical damage that resulted in mortality or delayed mortality.

While larvae and young juvenile pallid sturgeon in the LOMR may be susceptible to entrainment, and that entrainment may occur at some level, the entrainment rate and total number entrained in the LOMR cannot be estimated with accuracy due to lack of data. Some of the information needed to provide estimates of entrainment includes spawning locations, density of drifting larvae at various points within the water column, drift distance, diurnal drift patterns, and efficiency of dredge pumps in entraining water from various locations in the water column. Reine and Clark (1998) concluded that studies to date illustrate the difficulties in determining precise estimates of absolute entrainment rates and have seldom been able to determine population-level consequences with any degree of confidence.

The USACE, with the help of Holliday Sand and Gravel Company LLC. (Holliday), investigated the low likelihood of dredging entrainment resulting from the proposed action. This was estimated by comparing the amount of water within the dredging slurry versus the normal discharge rates in the Missouri River.

Water intake rates are predicated upon pumping rates and pump sizes. Holliday uses a Thomas P46 Dredge Pump capable of pumping 10,000 gallons per minute at 85 feet of total discharge head. The desired slurry for this setup is approximately 80% water by volume. Converting this value to cubic feet per second (cfs), the intake rate of Holliday's pump is 17.8 cfs. A typical Missouri River discharge in the Kansas City segment, where this dredge and pump are used, is approximately 44,000 cfs. Thus, the intake rates from Holliday's pump and dredge represent 0.04% of the entire Missouri River flow moving past the dredge at a given point in time. There is no substantial difference in pump sizes used amongst the Missouri River dredgers for the proposed action; these intake rates are an example of a pump running at optimal performance, continuously, which seldom occurs. The water being processed while dredging is underway represents a fraction of the water in the Missouri River system making the likelihood of dredging entrainment improbably low for the proposed action, thus minor and discountable.

It is also worth noting that the velocity of travel of propellers and the volume of water affected by propellers is greater than the volume of water passing through the hydraulic dredge pumps. Because the level of navigation propeller-induced mortality of pallid sturgeon in the LOMR was estimated to be extremely low (Section 6.1.1.1) and much less probable than that on the Mississippi River, the potential for pallid sturgeon entrainment and mortality in the LOMR due to dredging entrainment also is considered to be low and improbable and thus, minor and discountable.

Under the 2011 ROD, the level of commercial sand and gravel dredging in the LOMR changed little from previous years (2004–2008 levels); consequently, the 2011 DA permits were expected to result in little overall change in the potential for dredge pump entrainment. Individual fish mortality would likely be related to the distribution of dredging amounts among the river segments, as well as the seasonal distribution of the pallid sturgeon population. Despite over a decade of studies by the USACE's ERDC evaluating the susceptibility of sturgeon to entrainment through dredging and intake structures, no evidence of higher entrainment risk has emerged since the 2011 ROD (USACE 2011b) and the 2011 BA (USACE 2011a). The level of impact is expected to be the same under the proposed action as it was under the 2011 ROD, taking into account both reductions and increases in permitted tonnages proposed for permitting by the USACE in 2016 (Section 3.1).

6.1.1.3 Sound and Noise

Fish are capable of producing and detecting sounds, and these sounds affect and are used in a wide variety of fish behaviors (Zelick et al. 1999). Fish detect and respond to sound, using its cues to hunt for prey, to avoid predators, and for social interaction. Sound production has been recently discovered in several species of sturgeon (Johnston and Phillips 2003). Pallid and shovelnose sturgeon produce sounds during the breeding season. In a naturally turbid environment such as the Missouri River, sound cues may play a significant role in communication.

Underwater human-caused noise has also been documented to influence fish behavior in general (Nightingale and Simenstad 2001). Exposure to sound includes a measure of both the received level and the duration of the signal. For example, the received noise level can be expressed in terms of acoustic pressure, particle velocity, or intensity (energy flux), which all vary with time over the duration of the signal. Most noise effects on fishes have been observed in situations of intense energy flux, such as construction-related pile driving or explosions, or propeller and engine noise from high-speed boats.

Dredging operations generally produce lower levels of sound energy over prolonged periods (Nightingale and Simenstad 2001). Nightingale and Simenstad (2001) conducted a literature review of potential dredging-related noise effects on several fish species. The authors concluded that further research into the effects of noises specific to dredging are required to determine the potential effects of dredging noise on fishes. However, noise from the operation of dredges is expected to result in avoidance of the dredging area by fish species sensitive to noise over the duration of the activity. DeLonay et al. (2010) document spring migrations of reproductive pallid sturgeon to be 10's to 100's of kilometers, and migrations have been documented through some dredging reaches (such as Jefferson City, Waverly, and Kansas City). The effect of sound and noise associated with dredging, specifically on migrating reproductive sturgeon, has not been documented (Jacobson pers. comm.).

Sturgeon have been reported to hear sound frequencies in the range of sounds produced by dredging operations (J. J. Hoover, unpublished data as cited in Boyson and Hoover 2009); and it has been reported that dredging sounds could attract, disperse, or cause sturgeon to rise in the water column (Boyson and Hoover 2009). However, using radio telemetry, adult pallid sturgeon have been observed near dredging boats, which suggests that this species may not be particularly sensitive to dredging noise (DeLonay pers. comm.).

Based on the existing information, there appears to be no basis for concluding that noise from commercial sand and gravel dredging would affect pallid sturgeon.

6.1.1.4 Migration and Spawning

Over the past 10 years, research led by scientists at the USGS Columbia Environmental Research Center (CERC) and under the Comprehensive Sturgeon Research Project (CSRP) has considerably increased the understanding of pallid sturgeon migration, spawning, and spawning habitats. The research consists of several interdependent and complementary research tasks engaging multiple disciplines that primarily address spawning as a probable limiting factor in reproduction and survival of the pallid sturgeon. Data synthesized and reported from 2005–2008 (DeLonay et al. 2010) and new information from 2009 show consistent patterns of upstream spawning migrations in which sturgeon appear to be spawning at many locations and over a period of 1–2 months. Radio-tracking of pallid sturgeon has shown that females in the LOMR exhibit spawning behavior characterized by rapid upstream movement, stopping and then spawning within hours, followed by a variable intermittent downstream movement (DeLonay et al. 2010).

During these studies, spawning was verified by the recapture of females that had released their eggs after spawning and by observation of spawning aggregations with high-resolution sonar imagery. The CERC studies showed that wild and hatchery–origin pallid sturgeon are spawning at multiple locations in the LOMR; however, it is as yet unknown how many adults are spawning and whether any young are surviving to contribute to the population.

McElroy et al. (2011c) combined location data from pallid sturgeon implanted with telemetric tags and pressure-sensitive data storage tags with depth and velocity data collected with an acoustic Doppler profiler to document the conditions used by migrating sturgeon as they migrated up the LOMR to spawn in spring 2010. The results showed that, within a small margin, pallid sturgeon in the LOMR select least-cost paths as they swim upstream (typical velocities near 1.0–1.2 m/s); velocities in the main thalweg of the LOMR are generally more than twice these values. Within the range of collected data, it is also seen that many alternative paths not selected for migration are two orders of magnitude more energetically expensive (typical velocities near 2.0–2.5 m/s). In general, sturgeon migrated along the inner banks of bends, avoiding high velocities in the thalweg and crossing the channel where the thalweg crosses in the opposite direction in order to proceed up the inner bank of subsequent bends.

Thus, the research to date does not suggest that upstream migration and movement of adult sturgeon in the LOMR are limited. In addition, no comments are found within the related literature and reports regarding blockages or inhibition of movements during the spawning period. In general, upstream-migrating sturgeon appear to migrate upstream in the slower velocities of the inside bend, where commercial dredging is less frequently performed. These data support the hypothesis that migrating sturgeon utilize lower-velocity habitats on inside bends, presumably to minimize energy expenditure (Reuter et al. 2009). In addition to little evidence of avoidance of dredging operations by pallid sturgeon (e.g., due to disturbance, noise, or turbidity), there is little indication of effects of commercial dredging operations on spawning movements and migrations.

6.1.1.5 Suspended Sediment and Turbidity

Native aquatic species, such as pallid sturgeon, evolved in the LOMR under historically turbid conditions; turbid conditions that mimic the historical environment have largely been eliminated in the LOMR. At present, suspended sediment loads of the LOMR are from 0.2 to 17 percent of historical pre-dam values (Jacobson, Blevins, and Bittner 2009). Fish species that have become more abundant as turbidity has decreased include site-feeding species; some native fishes, such as pallid sturgeon, with morphological adaptations to use high-turbidity and high-velocity main-channel habitats have declined (Galat et al. 2005). The reduction in overall turbidity of the LOMR has affected the capability of pallid sturgeon and other native fish to forage successfully, which has increased competition with other non-native species (USFWS 2003).

Historical dredging operations in the LOMR have resulted in suspended sediment at the dredging sites and for some distance downstream within the sediment plume. USACE sampling below a cutter-head dredge in the LOMR near the confluence of the Kansas and Missouri Rivers demonstrated that suspended solid concentrations typically returned to background concentrations within approximately 1,300 feet (USACE 1990). The size of the elevated suspended sediment plume downstream of the dredge depends on a variety of factors, including the hydrodynamic conditions at the dredging site, the type of dredge used, operational methods, and sediment type. Dredging results in localized elevation of suspended sediment at and downstream of the dredges. However, the change in turbidity is anticipated to be short term and not substantially different from normally occurring levels under current conditions in the LOMR. Studies conducted by the USACE found that most organisms evaluated were relatively insensitive to the effects of sediment suspensions in the water and that, in general, dredging-induced turbidity is probably not of major environmental concern in most cases (USACE 1978).

Increased suspended sediment plumes downstream of the dredges would be expected under the LEDPA, although they are expected to be localized as described above. Pallid sturgeon are adapted to highly turbid waters and use turbidity as a cover habitat element. Decreased turbidity overall within the

LOMR may have increased predation risk to small sturgeons that have historically used elevated turbidity as cover from predatory fish (DeLonay et al. 2010).

Increased suspended sediment plumes would be expected to occur downstream of dredging activity, as described in the 2011 ROD; similar effects, although they are expected to be localized, are expected under the proposed action. Pallid sturgeon have evolved to inhabit areas of high turbidity and may even benefit from these increases. Decreased turbidity overall within the LOMR may cause increased predation risk to small sturgeons that have historically used elevated turbidity as cover from predatory fish (DeLonay et al. 2010). Because elevated suspended sediment plumes would extend only a short distance downstream of dredging activities (approximately 1,300 feet), dredging may result in a slight temporary beneficial increase in cover habitat to pallid sturgeon that are located downstream of dredging activities. Little or no effect on pallid sturgeon is expected from changes in suspended sediment or turbidity under the proposed action.

6.1.2 Potential Effects on Pallid Sturgeon Habitat

The physical and biological features of aquatic habitat important to pallid sturgeon can be generally defined by the following elements: (1) physical habitat with structural components known to be important for spawning, rearing, and feeding; (2) water conditions, such as water temperature, turbidity, and food availability; (3) river flow regime, which facilitates spawning migrations and larval and juvenile transport to rearing habitats; and (4) water quality suitable to support the various life stages of sturgeon in good condition. The following discussion focuses on the anticipated effects of the proposed action on pallid sturgeon in the context of the above elements.

6.1.2.1 Physical Habitat

Various habitats thought to be important to pallid sturgeon are currently excluded from dredging in the LOMR (Table 3-) and will continue to be excluded from dredging under the proposed action. In addition, the proposed action includes annual tonnage and dredging density limits within each of the five individually described segments of the LOMR (**Error! Reference source not found.**1. Consequently, the total annual level of dredging throughout the Action Area will be reduced slightly under the proposed action compared to the baseline, although dredging activity is expected to be distributed more broadly within each river segment relative to recent years. Spreading the dredging over a larger area is expected to reduce indirect habitat effects caused by locally intense dredging.

The overall magnitude and duration of direct effects on pallid sturgeon habitat would be determined by the area eventually dredged within each river segment, along with the time required for recovery and repopulation of the benthic habitat directly disturbed by dredging. Potentially, dredging may result in changes to pallid sturgeon habitat at and downstream of dredging sites throughout the Action Area, and these are discussed further below.

Potential Spawning Habitat

Laustrup, Jacobson, and Simpkins (2007) surveyed and mapped coarse substrate deposits and bedrock exposures within the LOMR. This survey provided an initial inventory of areas that may serve as sturgeon spawning habitat; approximately 219 acres of coarse substrate patches and bedrock were identified within the Action Area (Laustrup, Jacobson, and Simpkins 2007). The vast majority of the coarse substrate patches occur within the previously-established exclusion areas; most of the over 100 bedrock features are not within currently dredged areas. Only 0.4 percent, or approximately 0.8 acre of potential coarse patches habitat may be found outside of exclusion zones and would possibly be subject to dredging. This represents a small quantity of the mapped potential coarse substrate spawning habitat available in the Action Area.

Based on the current understanding of pallid sturgeon spawning habitats, commercial dredging is very unlikely to result in direct disturbance of these spawning habitats. Commercial dredging occurs predominantly in the deep, faster thalweg areas—in areas with sandy bottoms—and not in the revetted areas along outside bends. This is related to the locations of sand deposits and the permit requirements to avoid dredging outside of the RCL and to avoid the toe of revetted banks. In addition, the other suspected location of pallid sturgeon spawning, at the flow divergence immediately above shallower mid-channel bars are not typically used by dredgers.

DeLonay et al. (2010) suggest that spawning habitat availability is not a limiting factor in pallid sturgeon reproduction in the LOMR. Furthermore, dredging activities will not affect the flow conditions identified in USFWS (2014) as necessary for successful migration and spawning. Therefore, commercial dredging is unlikely to result in direct disturbance of known or suspected spawning habitats.

Benthic and Foraging Habitats

Dredging also can result in changes to benthic substrate composition and associated pallid sturgeon habitat downstream of dredging sites. As dredging removes sand and gravel, coarser and finer-grained materials are returned to the river bed. Depending on the type of dredge, coarse material is deposited on the river bed below the dredge or to the side of the dredge. As a result, rows of coarse material can form on the river bottom as the dredge moves up and down the river. Bed sediment can also become coarser below dredging operations as finer material is picked up by the river to replenish what was deposited in the dredging depression (Kondolf 1997). These effects are relatively local and tend to accumulate in the areas with the most dredging (Simons, Li, and Associates 1985).

The result may be localized alteration of benthic habitat used by pallid sturgeon. Data have not been collected to definitively characterize the dispersal patterns of coarse-grained sediment after dredging to determine how areas with altered sediment concentrations are used by pallid sturgeon or how long it may take for the river bed disturbed by dredging to regain important pallid sturgeon habitat characteristics. Large, stable substrates such as boulders and cobbles often support larger macroinvertebrates or more productive invertebrate populations than do unstable gravel and sand substrates (Gore 1985, Singhal and Mehrotra 2000). Harvey and Lisle (1998) reported that piles of cobbles produced by suction dredging probably have only minor, local effects on the abundance of aquatic organisms, and taxa that strongly select large, unembedded substrate might become more abundant where cobbles are piled.

Removal of substrate and benthic organisms at the dredging sites by entrainment would result in immediate localized effects on the benthic community (USACE 1998a, Harvey and Lisle 1998), but recovery of macroinvertebrates after such disturbances are typically rapid. This potential direct and indirect effect on pallid sturgeon would be confined primarily to the mid-channel areas where dredging would be allowed and to the area within the dredge suction field. The effects on pallid sturgeon foraging would likely be limited and temporary, given the fact that the proportion of the total foraging area of the river bottom dredged would be low, and the probability that alterations of the bottom substrates may produce equally productive fish and invertebrate habitats and greater substrate diversity.

Shallow-Water Habitat

Riverine habitat loss or alteration in the LOMR, especially loss of structurally complex shallow-water areas along stream margins and near sand bars, islands, backwaters, sloughs, chutes, and side channels, have been implicated as a strong contributing cause in the loss of several native Missouri River fishes (Johnson, Jacobson, and DeLonay 2006). Many of the research, resource management, and restoration plans and programs currently in place in the LOMR are designed to understand the role of SWH and to create more SWH through modifications of flow regime and channel geomorphology.

The critical role of such SWH condition, given their presumed importance to young pallid sturgeon, as one of the key limiting factors in the successful reproduction and recruitment of pallid sturgeon, is one of the leading hypotheses now being pursued by multiple researchers (Braaten at al. 2008; DeLonay et al. 2010).

SWH is an important riverine habitat in the LOMR that provides for primary and secondary productivity, forage fish production, and early life stage development for native Missouri River fishes (Hesse et al. 1993, 1989; Galat et al. 2005; Johnson, Jacobson, and DeLonay 2006; Johnson, and Dietsch 2009). SWH is recognized as a now highly-underrepresented aquatic habitat type that was characteristic of the historical Missouri River. Historical changes, such as flow alterations and channelization of the LOMR, likely have substantially decreased the availability of shallow, slow-moving water (Johnson et al. 2006). Further, the LOMR has been and still is affected by reduced sediment inputs; these are important to creating and maintaining the diversity of habitats used by native fish such as the pallid sturgeon for reproduction and survival (USFWS 2003). While the use of SWH by young fish is supported by general river ecology theory, LOMR-specific data documenting the use of this habitat type by certain fish, such as pallid sturgeon, are only now starting to become available (Sterner et al. 2009; USACE 2009c).

The 2003 BiOp (USFWS 2003) indicated that the portion of the LOMR between the Platte River, Nebraska and the LOMR confluence with the Mississippi River is lacking sediment transport and sediment availability, which is adversely affecting pallid sturgeon habitat development and maintenance (USFWS 2003). Further, the USFWS has stated that larval and juvenile pallid sturgeon are limited by the quantity of SWH that provides rearing and refugia habitat (USFWS 2003). While the 2003 BiOp concluded that pallid sturgeon are limited by the lack of SWH, others have indicated that additional studies and modeling are needed to clearly establish which aquatic habitats are limiting to the survival of sturgeon and other native fish populations (Johnson, Jacobson, and DeLonay 2006; DeLonay et al. 2009).

SWH was originally defined as aquatic habitat that is less than 5 feet deep with velocities of less than 2 feet per second, as measured during the August median discharge (USFWS 2003). Recent clarifications further refine the definition of SWH as habitat with a high degree of diversity in depth and velocity that contains dynamic alluvial processes.

River flows and the corresponding river stage fluctuate daily, seasonally, and annually within the highly modified LOMR, and the presence of SWH is highly sensitive to flow regime (Johnson, Jacobson, and DeLonay 2006). Availability of SWH is generally high at the lowest discharges when water is shallow and slow over marginal sand bars and when river discharges are just over bankfull stage (Johnson, Jacobson, and DeLonay 2006). As river flow and stage change, the quantity of aquatic habitat with shallow water and slow velocities changes. Additional studies are underway in the LOMR to better understand the role and importance of SWH and its locations, relationship to channel morphology, and flows (DeLonay et al. 2010).

Programs to Address Shallow-Water Habitat

The Missouri River Restoration Program (MRRP) seeks to mitigate near-term losses of Missouri River habitats and to recover threatened and endangered species. One of these important habitats is SWH that is particularly important to the pallid sturgeon. The program further seeks to restore the Missouri River ecosystem through habitat creation, flow modifications, and monitoring and research to prevent further declines of other native species. Programs are in place through the MRRP to create SWH through mechanical techniques and LOMR flow modifications (MRRP 2007). The USACE's Shallow Water Habitat Program aims to create habitat considered necessary for the recovery of endangered pallid sturgeon. Under the 1986 BSNP Wildlife Mitigation Project, the USACE began constructing chutes and backwaters in 1991 along the main channel, in an effort to restore SWH. As of 2001, these projects have been incorporated into the Shallow Water Habitat Program under BiOp compliance (NAS 2010).

The Reasonable and Prudent Alternatives in the 2000 and Revised 2003 BiOps required reconstruction or rehabilitation of 20 percent of the SWH that existed prior to construction of the BSNP. The project area for the Shallow Water Habitat Program extends from near Ponca, Nebraska downstream to the mouth of the Missouri River at St. Louis. Plans are to ensure that 20–30 acres of shallow/slow-water habitat per river mile exist below Ponca, Nebraska by 2020 to meet this requirement; the program is generally on target as of 2010 (NAS 2010).

Natural SWH in the Missouri River includes side channels, backwaters, submerged sandbar and bank line margins, and low-lying depressions in the floodplain adjacent to the channel. Using natural SWH as a model, constructed SWHs under the revised definition are expected to have a predominance of shallow depths intermixed with deeper holes and secondary side channels, lower velocities, and higher water temperatures than main-channel habitats (NAS 2010). The criteria for depth (<5 feet depth) and for velocity (<2 feet per second) may be modified as understanding of large-river ecology improves. The SWH structures in the main channel aim to enhance habitat diversity by creating zones of higher and lower flow through dike fields and in chute-like areas behind dikes and revetments.

Two types of SWH projects are being constructed: (1) habitat creation at the margins of the navigable portion of the main river channel; and (2) construction or modification of chutes and backwaters on floodplains (NAS 2010). Constructed chutes are intended to have a hydrologic connection to the main channel at both high and low flows, have active bed sediment transport, and provide habitats that mimic historical depth and velocity conditions. Chutes provide shallower, more complex habitat than is found within the navigation channel; and they are designed to evolve over time, developing sinuosity and sandbars (NAS 2010). Constructed backwaters are connected to the main channel at only one end and therefore provide habitat with lower flow velocities.

The use of chutes to enhance habitat diversity and promote river and ecosystem restoration is a relatively new practice, and there is only a small body of existing projects or research findings that could be used to guide Missouri River chute construction and adjustments (NAS 2010). Studies in the Missouri River are being led by USGS scientists within their larger body of research on river corridor habitat dynamics (see Jacobson et al. 2004). However, there are few other examples from within the United States or internationally of restoring floodplains of large rivers (NAS 2010); for example, see Buisje et al. (2002). The limited amount of past projects and substantive research results lends support for the adaptive approach to these projects that is being promoted by the USGS, the USACE, and others.

The effectiveness of SWH projects in the main channel, such as dike notching, bank notching, or chevrons, have been monitored under the Habitat Assessment and Monitoring Program (HAMP) since 2004. HAMP monitoring includes both biological response (fish species composition and richness) and habitat response (water depth, velocity, and substrate) to SWH creation, with sampling designed to relate these two components. The main findings to date are that fish use of SWH is highly variable in project and control reaches (Sampson and Hall 2009). It is not yet possible to draw clear conclusions about the biological effectiveness of the monitoring or the projects. Despite the ongoing monitoring, the NAS (2010) concluded that the SWH restoration program was slow to start, spotty, and incomplete, making it difficult to draw conclusions about successes and progress.

Earlier studies of geomorphology, physical habitat, hydrology, and ecological evolution of natural and created chutes have been conducted by scientists from outside the USACE (Jacobson et al. 2004, Jacobson 2006). Monitoring results of this project for 2006–2008 are summarized and analyzed in a 2009 report (Sterner et al. 2009), which includes monitoring of both fish response and geomorphic/habitat response (NAS 2010). SWH created through construction of chutes off the main channel, originally as part of the Missouri River Fish and Wildlife Mitigation Project, were evaluated.

Jacobson et al. (2004) reported that natural and engineered chutes (Cranberry Bend, Lisbon Bottom, Hamburg Bend, and North Overton Bottoms) were providing substantial amounts of SWH, proportionately considerable amounts of SWH in the context of the overall river reach, and providing SWH over a wider range of flows. For example, the 2.2-mile-long Lisbon Bottom chute provides as much as 50 percent of all of the SWH that exists within the accompanying 9.6-mile reach of the river.

Dredging's Effect on Shallow-Water Habitat

Sediment loads and sediment transport are important in the development of SWH in the LOMR, and sediment in transient storage during its passage along the river channels and floodplains of the Missouri River valley has value for habitat formation (NAS 2010). Creation and maintenance of SWH are brought about by sediment transport and deposition, which has been reduced from historical levels (USFWS 2003). River bed degradation has resulted from reduced sediment loading and an increased capacity of the LOMR to transport sediment. The ESH and SWH programs are reintroducing some sediment into the Missouri River, and are gradually reintroducing channel mobility and hydraulic connections between the main channel and its floodplain that support new habitat formation (NAS 2010).

Continued river bed degradation could affect the long-term stability and functioning of SWH restored by the MRRP (USACE 2009), but the relationship between bed degradation and sediment transport rates and SWH formation is only poorly understood. Examples of emerging scientific understanding of the performance of SWH projects are only now being published (e.g., Papanicolaou et al. 2010, McElroy et al. 2010b). The research of Papanicolaou et al. (2010), designed to quantify the additional SWH gained from notching these dikes and to evaluate their performance under different flow conditions, demonstrates the complexities involved. Their numerical simulations showed that the SWH criterion for depth was more difficult to satisfy in the study reach than the SWH criterion for velocity, and results from the study suggested that notching the dikes had limited impact on the SWH because the area gained from the bank line shift was offset by the area lost from the scour holes formation. Their research also showed that the performance of the SWH projects was highly discharge dependent; the dike projects could provide the minimum required SWH for some mean annual discharges but not for others.

Despite ongoing research and studies, there are no data or studies that address the relationship between the performance of SWH project and reach-scale changes in bed elevation, or to general or bed elevation changes (either aggradation or degradation). This paucity of information makes it difficult to assess the potential impacts of degradation or channel change on SWH projects. For the purposes of the effects analysis, it was assumed that river bed degradation, in conjunction with the local (reach-scale) removal of sand and gravel, could affect the quantity and distribution of natural or created SWH in the LOMR. Potential effects on naturally occurring SWH could result from changes in elevation, configuration, or connectivity of the SWH to the main river channel, or could affect the performance of SWH projects relative to design specifications.

Because the linkage between river bed degradation, sediment availability, and the quantity of SWH has not been quantified, levels of potential river bed degradation were used in the FEIS (USACE 2011) as a proxy for the potential for changes in the quantities of SWH. The geomorphology analysis in the FEIS described the estimated changes in average river bed elevations and low-flow and high-flow water surface elevations using the following three categories: slight change (less than approximately 2 feet); moderate change (approximately 2–4 feet); and substantial change (greater than approximately 4 feet). Under the Environmentally Preferred Alternative and the LEDPA, dredging would be kept to levels that would result in bed degradation and associated changes in low-flow and high-flow water surface elevations that would be expected to be only slight in the short term and long term. In order to address concerns and uncertainties regarding dredging effects to SWH, the 2011 ROD and BA specified an adaptive management framework. This framework requires a bed and water surface elevation survey in the fourth year of each permit cycle, with the USACE tasked with comparing the most recent surveys to baseline data to evaluate the "condition and trend of the river" and determine if additional measures should be taken to reduce impacts. The USACE may modify, suspend, or revoke the permit at any time if it determines that permit limits and special conditions are not adequately limiting the impact of dredging to no more than "slight degradation," defined as "less than approximately 2 feet" (USACE 2011). Moderate ("approximately 2–4 feet") to substantial ("greater than approximately 4 feet") degradation instead of the slight degradation anticipated for the St. Joseph, Waverly, Jefferson City, and St. Charles segments or any additional degradation in the Kansas City segment would require a thorough review of permit provisions, and could result in reductions in authorized dredging reaches or quantities, or implementation of other mitigation measures. Likewise, aggradation could allow for consideration of increased quantities.

Bed and Water Surface Studies

On July 14, 2015, the USACE-River Engineering Branch released a memorandum documenting recent bed and water surface elevation changes from 2009 to 2014 (2009–2014 Degradation Assessment;

USACE 2015, Appendix 1). The analysis period of the memorandum encompasses the recent dredging permit period, and thus puts recent and proposed dredging into context with bed elevation changes. Bed elevation change was measured at cross-sections spaced every 250-500 feet (Table 6-1). Water elevation changes were based on water surface profiles collected at discharges approximating the Construction Reference Plane (Table 6-1). The memo reports and analyzes average bed elevation for the LOMR 'hot spot" reaches identified in the FEIS (17, 5-mile reaches centered around sand plants), and the five dredging segments. While adequate for assessing net bed elevation changes, these average measurements do not directly quantify changes in SWH abundance. "Slight changes" in bed elevations affected by dredging would not adversely affect SWH for reasons described below. Thus, the discussion below uses average bed elevation changes as a surrogate for possible changes to SWH abundance.

Year	Data Type	# of Cross-sections (Spacing) / Water Surface Measurements
2008	Hydrographic survey	7326 (250 ft)
2009	Hydrographic survey	10550 (250 ft)
2012	Hydrographic survey	1302 (2000 ft)
2013	Hydrographic survey	10548 (250 ft)
2014	Hydrographic survey	5263 (500 ft)
1990	Water surface profile	180
2009	Water surface profile	164
2012	Water surface profile	174
2014	Water surface profile	174

Table 6-1 Data Sets used in Corps' 2015 Analysis of Bed Degradation

Table 6-2 presents the average change in elevation over the larger authorized dredging reaches. These data appear to be demonstrating that the LOMR, as a whole, is experiencing no more than slight degradation as predicted in the FEIS. It is also demonstrating the provisions set forth in the FEIS that limit extraction totals both spatial and temporally appear adequate and add stability back to certain river segments.

Segment Name	St. Joseph	Kansas City	Waverly	Jefferson City	St. Charles
River Miles	391 to 498	357 to 391	250 to 357	130 to 250	0 to 130
2009 to 2013 (ft)	-1.62	-0.41	0.13	0.08	-0.41
2009 to 2014 (ft)	-1.40	-0.36	0.30	0.28	-0.04

Table 6-2 Table showing average bed changes within Dredging Reaches

Adding to the table above, Figure 6-1 presents the bed change over 5-mile increments centered on each river mile in the LOMR. For example, the bed change shown at RM 350 is a mean of bed change values from cross-sections from river miles 352.5 to 347.5. From these data the USACE concluded that since 2009 the river bed has degraded upstream of the Kansas River (RM 366.5) but experienced slight deposition in Kansas City and Waverly Segments downstream of the Kansas River. Eighty-six percent of the reaches had a change of less than +/-1ft and ninety-nine percent of the 5-mile reaches experienced year-to-year variability of less than+/- 2 ft (Figure 6-1). This suggests that a 2 ft threshold is sufficient for determining persistent geomorphic change in a 5-mile reach; another way to state these findings is to say any observed change in the bed elevation of a 5-mile reach between +2 and -2ft, during a five-year window, is simply the natural variability in the bed forms unless a trend has been established.

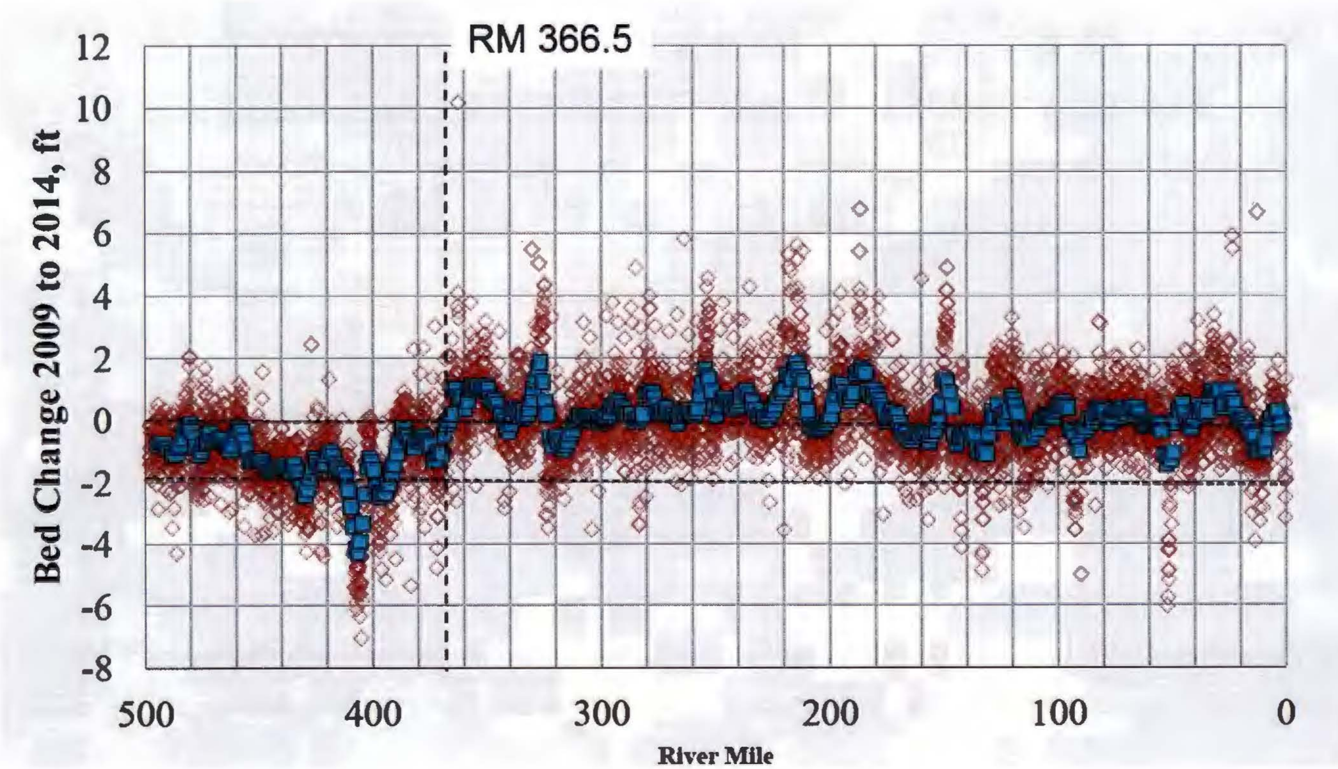

Figure 6-1 Comparison of individual cross-sectional bed change vs bed change averaged over five miles for 2009-2014. Figure also depicts the natural variability observed bed elevations from year to year which is plus/minus two feet.

In the FEIS the USACE identified 17 reaches of the LOMR that experienced degradation as a result of localized dredging intensity. As a result, a cap was placed on the amount of material that could be extracted from these degraded 5-mile segments (300,000 tons). The 300,000 ton threshold appears to be adequate at preventing future degradation in these areas. Recent surveys have indicated no further degradation has occurred in a majority of the Hotspots (Table 6-3); the exception would be within the Hotspots within the St. Joseph Segment, RM 391-498 (Table 6-3).

Hotspot RMs	Bed Change 2009 to 2013 (ft)	Bed Change 2009 to 2014 (ft)
15 to 20	-0.48	-0.16
25 to 30	-0.27	0.36
30 to 35	-0.02	0.87
90 to 95	-0.40	-0.59
95 to 100	-0.48	0.54
140 to 145	-0.73	-0.61
145 to 150	0.76	0.87
355 to 360	1.09	0.97
360 to 365	1.13	0.75
365 to 370	0.41	-0.13
370 to 375	-1.58	-1.29
375 to 380	-0.86	-0.55
380 to 385	-1.25	-0.90
385 to 390	-0.71	-0.33
390 to 395	-2.89	-2.07
445 to 450	-1.76	-1.46
450 to 455	-1.55	-1.36

Table 6-3 Average bed change in FEIS Hotspots

Of the entire LOMR, the 2015 USACE memo documents (19) 5-mile reaches with degradation greater than 2 feet from 2009 to 2014 (see Table 6-4). These reaches were all located upstream of RM 390 within the St. Joseph segment and do not appear to be spatially associated with dredging (Figure 6-2). A degradation trend was believed to be occurring in the St. Joseph segment prior the interpretation of the dredgers bathymetric surveys (Jacobsen et al. 2009). The authorized dredging tonnage amounts in the St. Joseph segment were small relative to other segments (Table 3-1), suggesting that the observed degradation greater than 2 feet in these areas is likely a result of geomorphic processes unrelated to dredging. Figure 6-2 shows that bed and water surface elevation changes had no identifiable correlation with dredging locations and quantities in the St. Joseph Segment, or throughout the remainder of the LOMR, due to the extraction restrictions set forth in the 2011 ROD.

Reach RMs	Bed Change 2009 to 2014 (ft)
390 to 395	-2.07
391 to 396	-2.07
392 to 397	-2.36
393 to 398	-2.41
394 to 399	-2.48
395 to 400	-2.35
396 to 401	-2.17
401 to 406	-2.42
402 to 407	-3.34
403 to 408	-3.95
404 to 409	-4.33
405 to 410	-4.19
406 to 411	-3.46
407 to 412	-2.82
408 to 413	-2.30
426 to 431	-2.23
427 to 432	-2.45
428 to 433	-2.44
429 to 434	-2.10

Table 6-4 5-mile reaches with degradation greater than 2 feet from 2009 to 2014

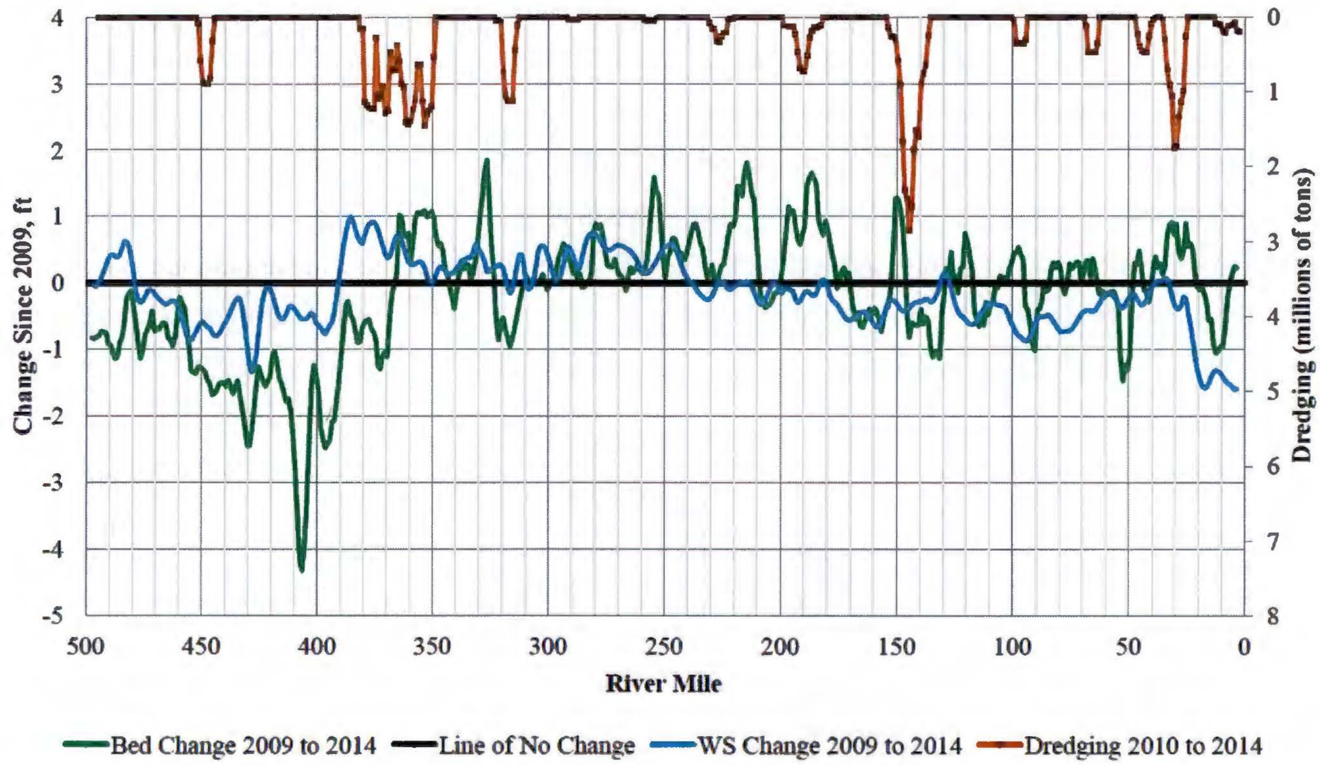

Figure 6-2 Changes since 2009 (Rolling 5-mile average): Bed Elevations, CRP-Flow Water Surface Elevations, and Cumulative Dredging

In 2011, the LOMR as a whole experienced bed degradation in immediate response to a major flood event, and then aggraded from 2012-2014 subsequently (Figure 6-3). These changes represent a major influence on bed elevation changes for the LOMR from 2009-2014, which suggests continued measurement of bed elevation change should be required to fully understand long-term sediment and bed dynamics in the LOMR as they relate to commercial dredging.

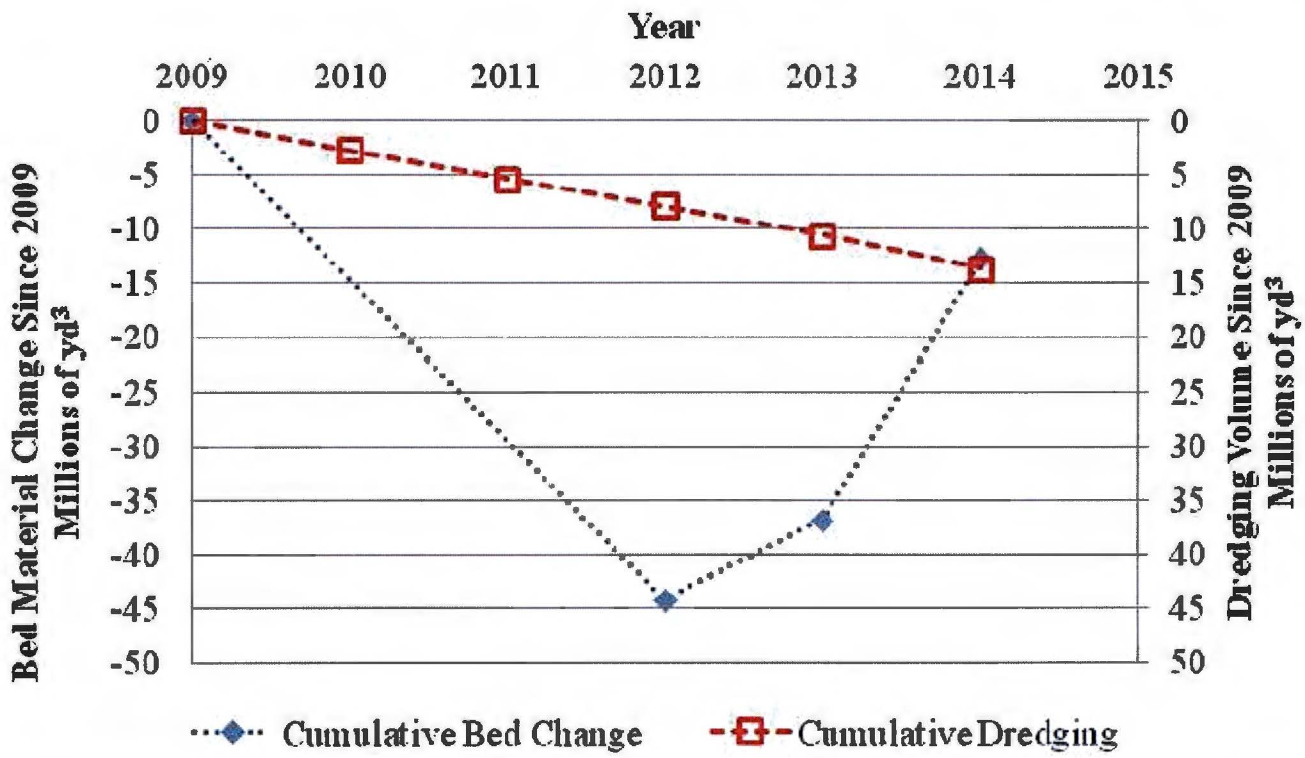

Figure 6-3. Changes since in Bed Material and Cumulative Dredging volume since 2009

Conclusion

The level of river bed degradation anticipated throughout the LOMR is not expected to result in any measurable impacts to the abundance of SWH over and above natural year-to-year variations in the abundance of SWH; bed elevation changes on the order of moderate (-2 to -4 feet) to substantial (>-4 feet) would likely be required for this to occur and data analyzed thus far do not show this trend; moderate to substantial degradation is not anticipated given the spatial and temporal restrictions placed on extraction across all Segments under the 2011 ROD and as part of the 2016 Permit Renewals.

Relative to 2011 permitted dredging tonnages, the proposed increases in dredged tonnage are largely focused in the Waverly reach, which has aggraded both historically (Jacobsen et al. 2009) and recently (USACE 2015, Appendix 1). In the St. Charles, Jefferson City, and Kansas City segments, the tonnages proposed under the Proposed Action are largely in line with 2011-2014 tonnages, a period that saw bed elevation changes in line with natural variability.

However, several reaches within the St. Joseph Segment showed degradation trends and values beyond acceptable limits. Thus, the USACE is proposing to decrease extraction totals in this Segment from 860,000 tons to 330,000 tons to prevent the exacerbation of degradation trends in the area.

Overall, degradation from 2009 to 2014 on the LOMR followed the predictable pattern seen during and after previous major floods; degradation during the flood followed by post-flood recovery to levels lower than before the flood. The distribution of the degradation from 2009 to 2014 was dominated by the effects of the 2011 flood, not by locations or intensity of dredging extraction.

The 2011 ROD and DA permits established Pallid Sturgeon Protected Areas where dredging was not permitted. While the 2009–2014 USACE memo (USACE 2015, Appendix 1) did not directly assess average bed changes in these protected areas, a majority of the protected areas are located in the St. Charles, Jefferson City, and Waverly segments that experienced either aggradation (Jefferson City and Waverly) or very slight degradation (St. Charles) from 2009 to 2014, suggesting that bed elevation changes, and changes in SWH abundance, were minimal in that period. In addition, many SWH projects are not designed to be static habitat alterations but rather to change and evolve over time in response to flow and sediment regime and design specifications (McElroy et al. 2010b, NAS 2010). Examples of research showing the evolving nature of SWH enhancement projects are provided by Jacobson (2006) and Jacobson et al. (2004). This means that some SWH projects could adjust to minor local changes in bed elevations as they evolve. Dredging avoidance near SWH projects in the LOMR is likely to prevent degradation in these areas. Because dredging is already excluded within 200 feet of dikes and revetments and 100 feet of natural bank lines and islands, SWH created by notching dikes should not be directly affected by dredging. The inlets and outlets of recently created and still evolving chutes also are protected from dredging so that the sediment supply needed for sandbar formation in the chutes is not disrupted.

Because current data are indicating the locations and currently authorized levels of dredging are not a dominant factor influencing the overall bed trends of the LOMR, the USACE has concluded that the effects of dredging on pallid sturgeon SWH are minimal and will result in no adverse affect on individuals or population levels as long as the spatial and temporal restrictions placed on extraction identified in the 2011 ROD [and Section 3.5 of this document] and proposed under the 2016 Permit Renewals are carried out.

6.1.2.2 Flow Regime

Stream flow is strongly related to many critical physiochemical components of rivers, such as dissolved oxygen, channel geomorphology, and water temperature, and can be considered a "master variable" that place bounds on the disturbance, abundance, and diversity of many aquatic plant and animal species (Power et al. 1995, Poff and Zimmerman 2010, Poff et al. 2010). The flow regime of the Missouri River and seasonal patterns of flows are essential ecological components of the life history of pallid sturgeon (DeLonay et al. 2009). Flow magnitudes and their timing are important for migration and spawning cues, flow regime strongly influences sediment transport and the development of riverine habitats, and flows strongly influence the amount of SWH (Johnson, Jacobson, and DeLonay 2006; Jacobson and Galat 2006).

The proposed action would not affect the flow regime of the LOMR, which is largely controlled by flow releases from upstream reservoirs. The proposed action would only indirectly interact with flow regime via related effects on sediment budget and rates of sediment transport. These effects are more thoroughly discussed in the FEIS (USACE 2011) and in the previous section on SWH.

6.1.2.3 Alteration of Water Quality

Under the 2011 ROD, dredging was increased or decreased depending on the river segment and was expected to change and be evaluated periodically through an adaptive management framework. Increased dredging would increase the potential for local re-suspension of contaminants embedded within the substrate. Background sediment contamination in the LOMR is likely, but the degree of contamination has not been extensively documented (Jacobson et al. 2008). Various levels of pesticides and metal concentrations have been measured in sediments at various locations in the LOMR (Jacobson et al. 2008, Poulton 2010, Echols et al. 2008). Buckler (2011) indicated that survival, reproduction, and development of *Scaphirhynchus* spp. individuals may be affected by PCBs, organochlorine pesticides, and polybrominated diphenyl ethers, contaminants that have been documented in area sediments and fish tissues (USFWS 2014). Dredging under the proposed action would increase the number of localized areas where sediment at and downstream of the dredging site would be temporarily suspended.

Construction of shallow-water habitat enhancements shares some techniques and impacts with commercial dredging. Concerns about water quality impacts from SWH construction have led to commitments to study nutrient and sediment contributions to the Missouri and Mississippi rivers from SWH projects (Corps 2011d). Gosch et al. (2013) concluded that SWH chute construction projects were unlikely to significantly increase Missouri River nutrient concentrations initially or as these chutes continue to develop. Heimann (2015) found that sediment from side-channel chute construction associated with SWH restoration accounted for a "small portion of total nutrient and sediment transport" in the Missouri River.

Under the proposed action, the level of re-suspension of contaminants is expected to decrease in the Kansas City segment due to reduced dredging and the subsequent disturbance of potentially contaminated sediments. The reduction is anticipated to result in a minor improvement in water quality at a local level. In addition, decreased dredging activity in this segment would result in a reduced risk of spills and leaks and the introduction of oil, fuel, or other contaminants into the Kansas City segment.

The number of areas within the St. Joseph and Waverly segments with possible contaminants temporarily re-suspended was anticipated to increase under the 2011 ROD. Because the currently proposed action shifts dredge tonnage from the Kansas City segment to the Waverly segment, additional contaminants may be suspended in those areas. Dredging vessel trips are expected to increase, accompanied by a small increase in the risk of vessel incidents (i.e., spills, leaks, and collisions) in this segment.

Within the Jefferson City and St. Charles segments of the LOMR under the proposed action, dredging would continue as it has recently. Dredging in these segments is expected to result in temporary resuspension of possibly contaminated sediment into the water column at a rate similar to expected rates under the 2011 DA permits. Dredging vessel numbers are expected to remain the same; therefore, the risk of dredging vessel spill incidents would not change.

6.2 PIPING PLOVER

Due to impoundment and channelization, virtually no piping plover nesting habitat is located in the Action Area (USFWS 2003). No portion of the LOMR in the Action Area has been designated as critical piping plover habitat (USFWS 2002). Piping plovers are a transient species that rarely occur in Missouri during migration between wintering grounds and breeding areas (The Audubon Society of Missouri 2009). Migration habitat use is poorly understood, but plovers likely use inland and coastal stopover sites when completing this migration (USFWS 2008). The importance of the Missouri River as migration habitat is unknown (USFWS 2003). Typically, piping plover migration between wintering and nesting habitats peak in spring and fall (USFWS 2008).

Due to the lack of suitable nesting habitat, the rare occurrence of this species during migration, and the lack of critical habitat in the Action Area, dredging under the proposed action is not likely to affect piping plover populations or their nesting habitat.

6.3 INTERIOR LEAST TERN

Small flocks of interior least terns migrate between wintering and nesting habitat through Missouri from late-April to mid-May and from August through September (MDC 2011c). Although interior least tern breeding habitat historically was located along the Missouri River (USFWS 1992), a 2005 range-wide interior least tern survey (Lott 2006) did not identify any least tern nest sites along that river in Missouri; and no nest sites were observed on the Missouri River south of its confluence with the Lower Platte River in Nebraska. Suitable sand bar nesting habitat has been eliminated in the Action Area because of river channelization and operations (Smith and Renken 1991, USFWS 2003); past channelization projects along the LOMR have resulted in a 97-percent reduction in sand bar areas (Galat et al. 2005).

While interior least tern individuals may occur along the LOMR during migration, nesting has generally not been found to occur within the Action Area. However, by comment on the Draft EIS (USACE 2011c) from the USFWS, some nesting occurs in Council Bluffs at the energy facility adjacent to the river, located in Iowa approximately 80 to 100 miles north of Rulo. Nesting has been documented near Council Bluffs, Iowa, (IDA 2010) which is more than 80 miles north of the Action Area. Historically, the interior least tern nested along the LOMR to St. Louis, Missouri (USACE 2004a); therefore, this species may use the LOMR for breeding if suitable nesting habitat was present. Due to the general lack of suitable sandbar nesting habitat currently in the Action Area and the lack of breeding birds in the Action Area, dredging under the proposed action is not likely to affect interior least tern populations or their nesting habitat.

6.4 NORTHERN LONG-EARED BAT

During summer, northern long-eared bats roost singly or in colonies underneath bark, in cavities, or in crevices of both live and dead trees. Males and non-reproductive females may also roost in cooler places, like caves and mines. Northern long-eared bats emerge at dusk to fly through the understory of forested hillsides and ridges feeding on moths, flies, leafhoppers, caddisflies, and beetles, which they catch while in flight using echolocation. This bat also feeds by gleaning motionless insects from vegetation and water surfaces. Northern long-eared bats spend winter hibernating in caves and mines, called hibernacula. They typically use large caves or mines with large passages and entrances; constant temperatures; and high humidity with no air currents.

Current threats to the species include changes in summer habitats, the reduction in roosting and foraging forested habitat, and white-nose syndrome (USFWS 2015). Critical habitat for the Northern long-eared bat has not been designated. Because Northern long-eared bats are located in terrestrial areas and there is no designated critical habitat for this species, dredging under the proposed action will have no affect on this species.

6.5 INDIANA BAT

Indiana bats are permanent residents throughout the Action Area (Natureserve 2009). Between early spring and autumn, Indiana bats migrate to and use summer roosting and foraging areas located in riparian, floodplain, and upland forests (MDC 2010b, USFWS 2007b). Because Indiana bats are located in terrestrial areas, this species and their habitat are unlikely to be affected by the quantity of LOMR dredging under the LEDPA or any of the alternatives.

Between 2007 and 2009, the Missouri population of Indiana bat declined by 14 percent (USFWS 2010b). Current threats to the species include changes in summer habitats from alterations to land cover, the reduction in roosting and foraging forested habitat, and white-nose syndrome (MDC 2010b, USFWS 2010b). Critical habitat for the Indiana bat has been designated only in caves that contain winter roosting habitat (USFWS 1976); therefore, dredging under the proposed action would not affect designated critical habitat for the Indiana bat.

6.6 DECURRENT FALSE ASTER

The distribution of decurrent false aster is restricted to the portion of the Mississippi River floodplain south of the confluence of the Illinois River with the Mississippi River (MDC 2010c, Natureserve 2009). Decurrent false aster has the potential to occur along Missouri River floodplains in St. Charles County, Missouri (in the St. Charles segment) (MDC 2010c). The primary threat to the decurrent false aster is the loss of suitable wetland habitat (MDC 2010c).

No direct effects on the decurrent false aster from dredging would occur under the proposed action. Because the decurrent false aster colonizes margins around previously inundated open water wetlands (MDC 2010c), lowering of the water elevation in open water wetlands within this small area could allow this species to establish in newly exposed areas. Therefore, indirect effects on decurrent false aster located in St. Charles County, Missouri could potentially include alteration of wetland habitat due to LOMR river bed degradation and the associated changes in surface water and alluvial aquifer elevations. However, this potential is remote because the water surface elevation and alluvial aquifer elevations are not likely to change near the confluence because of the backwater effect of the Mississippi River. The proposed action includes no additional land clearing and the level of dredging proposed to be authorized combined with the backwater effect of the Mississippi River should result in no effect on the false aster.

SECTION 7

Determination of Effect

In fulfilling its obligations under Section 7(a)(2) of the Endangered Species Act, the information presented in this biological assessment represents the best data currently available to assess the potential effects of commercial sand and gravel dredging on five federally listed species in the LOMR, including: pallid sturgeon, *Scaphirhynchus albus*; least tern, *Sterna antillarum*, piping plover, *Charadrius melodus*; Northern long-eared bat, *Myotis septentrionalis*, Indiana bat, *Myotis sodalis*; and decurrent false aster, *Boltonia decurrens*.

After reviewing the current status of the listed species, the environmental baseline for the Action Area, the effects of the proposed action, and the cumulative effects, the USACE concludes that the proposed action would have the following effects on federally listed species within the Action Area.

Species	Federal Status	Effect Determination
Pallid sturgeon, *Scaphirhynchus albus*	Endangered	May Affect, Not Likely to Adversely Affect
Least tern, *Sterna antillarum*	Endangered	May Affect, Not Likely to Adversely Affect
Piping plover, *Charadrius melodus*	Threatened	May Affect, Not Likely to Adversely Affect
Northern long-eared bat, *Myotis septentrionalis*	Threatened	No Effect
Indiana bat, *Myotis sodalis*	Threatened	No Effect
Decurrent false aster, *Boltonia decurrens*	Threatened	No Effect

7.1 PALLID STURGEON

Throughout their range, pallid sturgeon are affected by numerous environmental factors. For example, pallid sturgeon survival and reproduction are affected by water temperature, predation, illegal harvest, contaminants, invasive species, sediment reductions, habitat availability, and magnitude of seasonal floods, among other factors (Wildhaber et al. 2007). The relative importance of each factor and how their importance rankings may change over time are not adequately understood. Intensive management of the Missouri and Mississippi Rivers has resulted in dramatic physical changes to these rivers. Changes in flow, channel morphology, water quality, and biota have been implicated as causative agents in the dramatic declines in native river fishes and their resource base in general, and with the decline of pallid sturgeon in particular. Commercial sand and gravel dredging occurs within this broader context of drastic changes throughout the LOMR; commercial dredging has occurred throughout the last century, but has increased in recent years to its current higher levels, though its effects are poorly understood.

When combined with the past and present effects, along with those anticipated as a result of future non-federal actions within the Action Area, the proposed action may affect, but is not likely to adversely affect pallid sturgeon. Based on the best available information reported in the literature and the specific factors on the LOMR, the potential for entrainment of adult pallid sturgeon due to dredging and towboat propellers and related mortality would be extremely low and improbable and thus judged to be minor and discountable. These conclusions are supported by studies where sturgeon entrainment was found to be low, as well as by other studies that found no entrainment of pallid sturgeon.

Without considering the context of the proposed action, drifting larvae appear be susceptible to dredging entrainment while in their free drift state. However, the water being processed while dredging is underway represents a fraction of the water in the Missouri River system at any given point in time. Thus, the USACE is led to conclude the proposed action's potential to adversely affect the pallid sturgeon during the larval drift period is improbably low, thus minor and discountable.

Assuming post-drifting, age-0 pallid sturgeon utilize Missouri River habitat features in the same way as larval shovelnose sturgeon, entrainment of pallid sturgeon should not occur post-drift stage. Dredging will only be authorized within the Rectified Channel Lines of the Missouri River, outside of the habitats post-drift stage larval sturgeon have been found to be predominately utilizing. Although the thalweg was not extensively sampled as part of recent Corps age-0 sturgeon sampling efforts these data and our current understanding of sturgeon life history indicate habitat features that routinely hold post-drift stage, age-0 sturgeon do not overlap with permitted dredging zones.

The other potential adverse effect of dredging on pallid sturgeon is through indirect effects on natural or created SWH, which is thought to be an important habitat to larval and juvenile pallid sturgeon. However, the effects on SWH are estimated to be minor and insignificant; these claims are supported by the USACE's analysis of the bathymetric data presented in Section 6 of this document. Under the proposed action, dredging levels for the entire LOMR, each segment, and the most degraded reaches would be kept to levels expected to result in no more than slight bed degradation and associated changes in low-flow and high-flow water surface elevations in the short term (5 years) and long term. Changes of this magnitude are not expected to result in any substantial impacts on the abundance of SWH over and above natural year-to-year variations in the abundance of SWH, Many of the SWH projects in the LOMR also have protection from the localized effects of commercial sand and gravel dredging because they are within, partially within, or adjacent to dredging exclusion areas. Additionally, annual water surface profiles and a bed elevation survey in the fourth year of each five-year permit cycle were and will be used to monitor and to ensure that bed degradation is not more than expected and that SWH is not lost.

Of the other potential effects of the proposed action, all were judged to be minor and discountable. These include:

- Based on the existing information, there appears to be no basis for concluding that noise from commercial sand and gravel dredging would adversely affect pallid sturgeon.
- There is little evidence of avoidance of dredging operations by pallid sturgeon (e.g., due to disturbance, noise, or turbidity), and there is little indication of effects of commercial dredging operations on spawning movements and migrations.
- Based on the current understanding of pallid sturgeon spawning habitats and resource protection zones, commercial dredging is very unlikely to result in direct disturbance of known and suspected pallid sturgeon spawning habitats.
- Increased elevated suspended sediment would have little effect on pallid sturgeon, a species adapted to high levels of turbidity; and plumes downstream of dredging activities may result in a slight temporary beneficial increase to no change in cover habitat to pallid sturgeon that are located downstream of dredging activities.
- The effects of dredging on pallid sturgeon foraging would likely be limited and temporary, given that the proportion of the total foraging area of the river bottom dredged would be low, and the probability that alteration of the bottom substrates may produce equally productive fish and invertebrate habitats and greater substrate diversity.
- The proposed action would not affect the flow regime of the LOMR, which is largely controlled by flow releases from upstream reservoirs.

- The effects on dredging on water quality would be minor, and although there may be an increase in some contaminants liberated from bottom sediment, these levels would be very low and rapidly diluted in the river.

Overall, commercial dredging in the LOMR is not Likely to adversely affect the pallid sturgeon and their habitat.

7.2 INTERIOR LEAST TERN

Commercial dredging on the LOMR is not likely to adversely affect interior least tern due to the lack of suitable nesting habitat within the Action Area, the rare occurrence and lack of breeding interior least terns within the Action Area, and the absence of critical habitat in the Action Area.

7.3 PIPING PLOVER

Due to impoundment and channelization, virtually no piping plover nesting habitat is located in the Action Area (USFWS 2003). No portion of the LOMR in the Action Area has been designated as critical piping plover habitat (USFWS 2002). Piping plovers are a transient species that rarely occur in Missouri during migration between wintering grounds and breeding areas (The Audubon Society of Missouri 2009). Due to the lack of suitable nesting habitat, the rare occurrence of this species during migration, and the lack of critical habitat in the Action Area, dredging under the proposed action is not likely to affect piping plover populations or their nesting habitat.

7.4 NORTHERN LONG-EARED BAT

Northern long-eared bats are permanent residents throughout the Action Area. Because Northern long-eared bats are located in terrestrial areas, this species and their habitat would not be affected by commercial dredging under the proposed action. Critical habitat for the northern long-eared bat has not been designated.

7.5 INDIANA BAT

Indiana bats are permanent residents throughout the Action Area (Natureserve 2009). Because Indiana bats are located in terrestrial areas, this species and their habitat would not be affected by commercial dredging under the proposed action. Critical habitat for the Indiana bat has been designated only in caves that contain winter roosting habitat (USFWS 1976); therefore, the proposed action will not affect designated critical habitat for the Indiana bat.

7.6 DECURRENT FALSE ASTER

No direct effects on the decurrent false aster from dredging would occur under the proposed action. Because this species has not been identified in the Jefferson City, Waverly, Kansas City, or St. Joseph segments, no direct or indirect effect on the species would be associated with sand plant construction in these segments. Indirect effects in St. Charles County, Missouri are unlikely or nonexistent because water surface elevations and groundwater levels are not expected to change due to the backwater effect of the Mississippi River.

SECTION 8

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8.1 PERSONAL COMMUNICATIONS

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